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A study of the use of negotiable certificates of deposits by large US banks to satisfy liquidity, profitability, and soundness needs

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A study of the use of negotiable certificates of deposits by large U.S. banks to satisfy liquidity, profitability, and soundness needs

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LIST OF SYMBOLS USED

A:	Measure of liquidity
a_i:	Weights in the liquidity definition
BF:	Borrowings from Federal Reserve
CD:	Negotiable certificate of deposit
CIPC:	Cash items in the process of collection
Δ:	Change in variable--first difference
DD:	Net demand deposits
E:	Expected value
E$:	Eurodollar borrowings
$E\$_b$:	Reserve free base for Eurodollar borrowings
FF:	Federal funds
GS:	Government securities
i_{BF}:	Federal Reserve discount rate
i_{CD}:	Offer rate on 90 day CD's
i_{CDS}:	90 day secondary CD rate
i_{CP}:	Interest rate on 1-4 month commercial paper
$i_{E\$}$:	Interest rate on 90 day Eurodollars
i_{FF}:	Interest rate on federal funds
i_{GS}:	Interest rate on government securities
i_L:	Interest rate on commercial bank loans
i_{TB}:	Yield on 90 day Treasury Bills
i_{TD}:	Interest rate on time and savings deposits
L:	Commercial bank loans
π:	Profits

PI: U.S. personal income

QC: Regulation Q ceiling

R: Reserves

r_1: Reserve requirement rates on net demand deposits

r_2: Reserve requirement ratio on savings deposits and CD's

r_3: Marginal reserve requirement of Eurodollar borrowing

S: Measure of soundness

SC_1: Service charge on demand deposits

SC_2: Per unit cost of servicing demand deposits

s_i: Weights in the soundness definition

X: General notation for an independent variable

Y: General notation for a dependent variable

Y*: Desired level of Y

Z: $(i_{TB} - i_{CD}) + (i_{FF} - i_{CD}) + (i_{BF} - i_{CD}) + (i_{E\$} - i_{CD})$

CHAPTER I. THE HISTORY OF THE NEGOTIABLE CERTIFICATE OF DEPOSIT AND LITERATURE REVIEW

Commercial banks, savings and loan associations, savings banks, and insurance companies are examples of financial institutions. The nature of their assets, largely claims on other institutions and individuals, sets them apart from other forms of business. However, it is the liability side of the commercial bank's balance sheet that sets it apart from other financial institutions. While most financial institutions receive and hold funds of the public, only commercial banks can maintain deposits (demand deposits) that are directly transferable by check.

Banks also maintain another category of deposits, the time deposit, which is not transferable by check. The technical distinction between demand and time deposits was first set forth in the National Bank Act of 1863 which stated

> ...demand deposits...comprise all deposits payable within thirty days and time deposits shall comprise all deposits payable after thirty days.

Today, the Federal Reserve System further classifies time deposits into three categories: (1) savings deposits, (2) time certificates of deposits (CD's) and (3) time deposit, open account.[1] Savings deposits may only be held by individuals or nonprofit organizations such as clubs and fraternal organizations. On the other hand, no restrictions are placed on the ownership of time certificates of deposits (CD's) or time deposits, open account. Time deposits, open account are generally used for special purposes such as Christmas Clubs or vacation clubs. The open

[1]Regulation Q, Section 217.1, page 3, Board of Governors of the Federal Reserve System.

account is evidenced by a contract stating the terms of deposit and may be increased by the depositor, usually by certain minimum amounts over the life of the contract. CD's represent the deposit of a fixed amount which the bank agrees to pay back in a specified period of time (30 days or longer) plus a specified amount of interest. The CD may be issued in transferable form (negotiable) allowing it to be transferred from one individual or organization to another before maturity or it may be issued in nontransferable form (nonnegotiable). The holder of a nonnegotiable CD, under normal conditions, must wait until his CD matures in order to get his funds. It is with the large negotiable CD, where large means $100,000 or more, that this study is concerned. Unless otherwise stated the abbreviation CD will be used to represent large negotiable CD's.

The next section of this chapter is provided as background for those not familiar with the CD.[2]

Development of the Negotiable CD

The time certificate of deposit is not a new instrument to commercial banking. Time certificates of deposit have been used by Midwestern and Southern banks since the early 1900's. While early CD's were issued on a negotiable as well as a nonnegotiable basis, the former were not truly marketable since no secondary market existed in which they could be sold and had only legal negotiability in that they could be transferred from one individual to another. Large New York City banks would not issue certificates of this type to corporations and in general were strongly

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[2] For a complete and detailed discussion of the CD's early development, see A. Gilbert Heebner's unpublished dissertation [14].

reluctant to issue time deposits to corporations. The reasoning behind this reluctance was the belief of the bankers that funds would flow from demand deposits to time deposits with the prospect of increased costs to bankers. By law no interest could be paid on demand deposits while interest could be paid on time deposits up to a maximum rate by law.

On February 20, 1961, the First National City Bank of New York broke this tradition and announced that it would offer CD's to both individuals and corporations in minimum amounts of $1,000,000. At the same time, Discount Corporation of New York City, a dealer in U.S. Government securities, announced that it would maintain a secondary market in the CD's issued by the First National City Bank. The creation of a secondary market not only added to the negotiability of the CD's but provided marketability as well. Following this announcement, major banks in New York City and other large cities also announced a readiness to issue CD's to corporations. These banks indicated that, in keeping with the rates of other money market instruments, offering rates would be determined from day-to-day, subject to Regulation Q interest rate ceilings. According to the banks, the principal reason for issuing CD's to corporations was to attract those funds lost when corporations used their idle balances to purchase existing money market instruments.

As can be seen in Figure 1.1, CD growth between 1961 and the present was not steady and CD volume dropped sharply in 1966 and 1969. Maintenance of Regulation Q ceilings below money market rates during 1966 and 1969 greatly limited the CD's competitiveness (discussion of Regulation Q and its administration will be deferred until Chapter II).

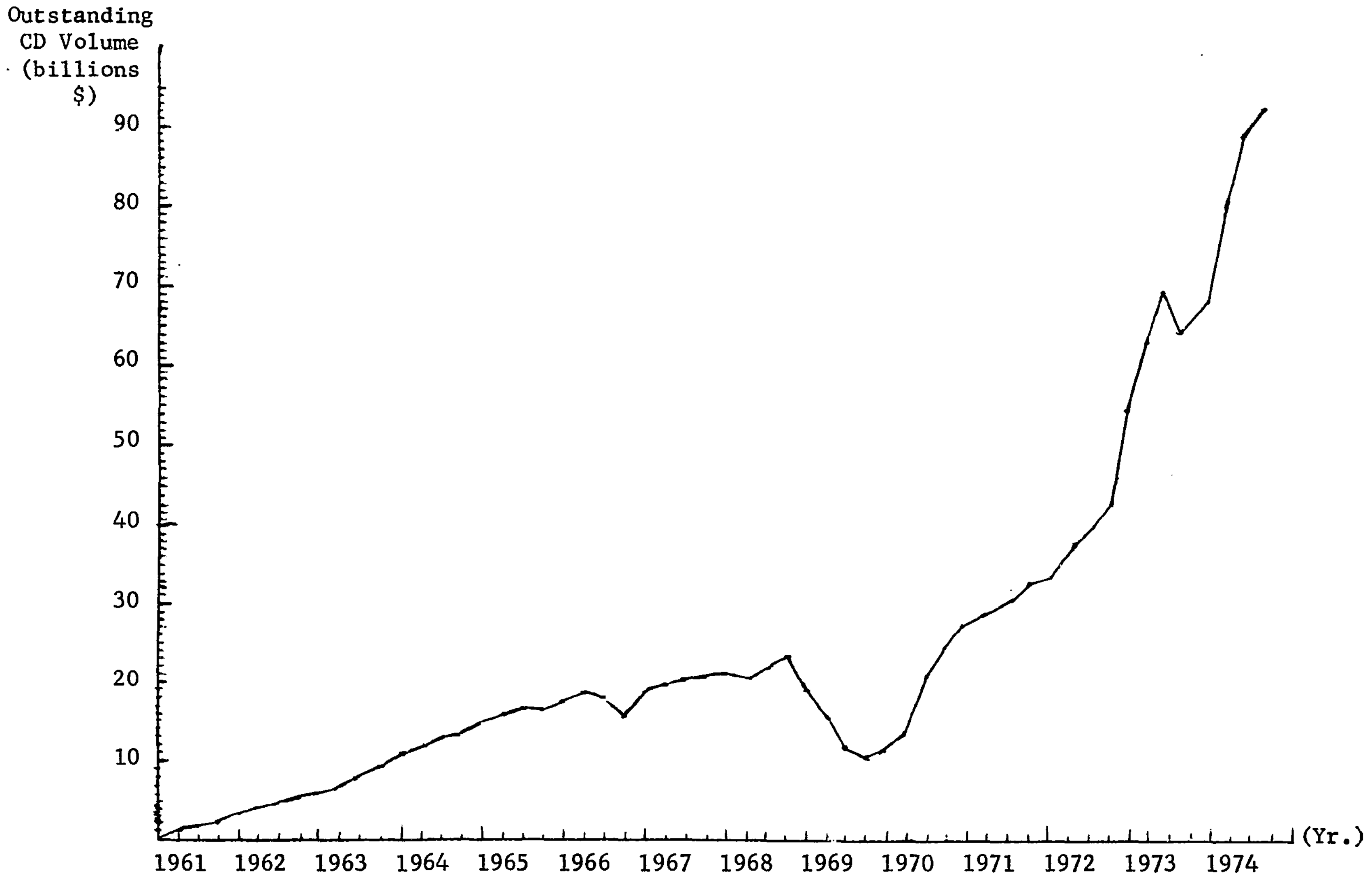

Figure 1.1. Volume of outstanding negotiable certificates of deposit (quarterly levels).

CD Characteristics

CD's have been offered in a variety of denominations, ranging from $25,000 to $10,000,000. Actual certificate size depends upon the size of the issuing bank and the needs of its customers. Smaller banks account for the CD's at the lower end of the denomination range. More typically the denominations are $100,000, $500,000 and $1,000,000. The larger New York City banks (those with deposits greater than $1 billion) generally dislike issuing CD's below $1,000,000.

Issuers: prime, lessor-prime, and off-prime

As the CD market grew in size, buyers in both the primary and secondary markets developed classifications of banks issuing large CD's. A bank is classified as either prime, lessor-prime or off-prime according to the relative marketability of its CD's. The prime group consists of 12 to 30 banks, lessor-prime group consists of about 45, and all other issuers are classified as off-prime. Prime banks generally have deposits exceeding $1 billion and account for the largest share of CD's.

Issue rates

The prime group of banks issue CD's at the "best" rates when regulation Q ceilings permit--about one-fourth of a percentage point above rates on comparable maturities of U.S. Treasury bills. Certificates of the lessor-prime group of banks carry a spread of 5 to 10 points about the "best" rates.[3] Other issuers--the off-prime group--generally must pay

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[3] A point is .01 of a percentage point, thus there are 100 points in one percent.

one-eighth to one-fourth of a percentage point more than prime banks, although they may negotiate special rates with particular customers. Also all rates may be slightly higher if the CD denomination is less than $1,000,000. Some smaller banks which are well known and respected in communities outside the major money markets of New York City may tap regional markets at the same and sometimes lower rates of interest. Certificates are issued and traded on a yield to maturity basis with 360 days considered one year.

Secondary market

Development of a secondary market for CD's began early in the spring of 1961 with the announcement of the Discount Corporation of New York that it would provide a market--that is maintain an inventory and buy or sell at quoted rates. Other nonbank dealers in U.S. government securities entered the field and the core of the secondary market developed around five leading financial houses; the other four members of this group consisted of Salomon Brothers & Hutzler, First Boston Corporation, C. J. Devine and Co., and New York Hanseatic Corporation. Several Bank dealers in U.S. government securities joined the nonbank dealers in 1965 and 1966. Among those joining were Bankers Trust Company, Bank of America, and the First National City Bank of New York.

CD maturities

Data has been available since 1964 on the maturity distribution of CD's.[4] During the period from 1964 to 1974 the average monthly maturity of all outstanding CD's has varied from 2.0 months to 4.4 months (see Figure 1.2). A slight downward trend in maturity was present from 1964 through early 1968.[5] From 1968 through 1972 no appreciable trend was present.

A breakdown of CD maturity by size of bank indicates that there is a tendency for CD maturity to vary proportionately with bank size. In four of the seven years from 1965 to 1971 this relationship held across all four size classifications used (see Table 1.1).

Geographic distribution

While the volume of CDs issued by each of the twelve Federal Reserve Districts has increased sharply since 1961, the respective share of outstanding CD's has remained relatively constant. Since 1961, three districts, New York, Chicago, and San Francisco, have accounted for the bulk of outstanding CD's. The New York District, primarily through CD sales by New York money market banks, has consistently accounted for one third of available CD's. New York's portion reached a peak in 1965, reaching nearly 48 percent of outstanding CD's, and a low in 1969 with slightly over 31 percent of outstanding CD's.

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[4]Federal Reserve Board Statistical Release G.9: Maturity Distribution of outstanding Negotiable Time CD's in U.S.

[5]Trend was established by using linear regressions with seasonally adjusted values of maturity as the dependent variable and time as the independent variable. The coefficient of time was not significant for the period 1968 to 1972.

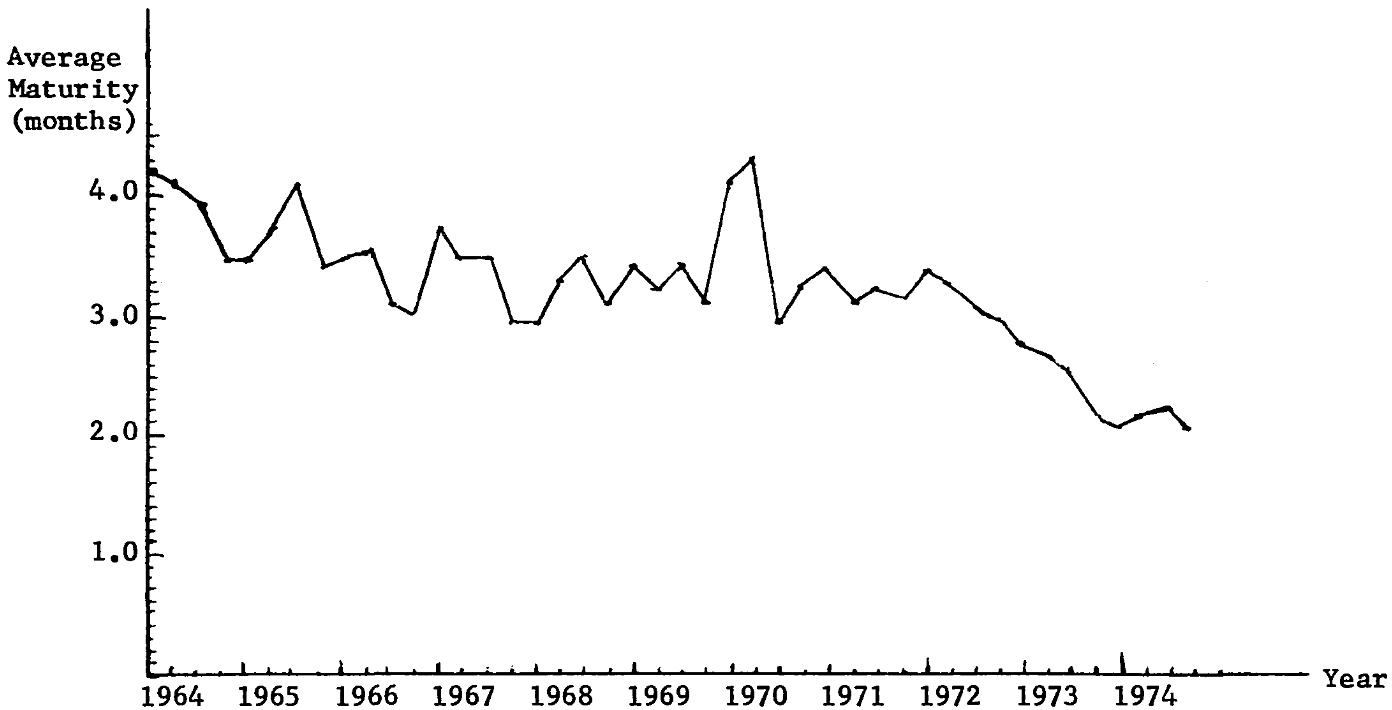

Figure 1.2. Average maturity of all outstanding negotiable certificates of deposit (quarterly levels)

Table 1.1. Annual average of CD maturity length expressed in months

Year	Bank Size Under $200 million	$200-$500 million	$500 million -$1 billion	$1 billion and over
1965	4.2	3.8	3.5	3.8
1966	3.6	3.6	3.4	3.4
1967	3.0	3.4	3.4	3.5
1968	2.8	3.2	3.2	3.3
1969	2.8	3.2	3.3	3.4
1970	3.6	3.8	3.7	3.5
1971	3.1	3.0	3.2	3.2
1972	3.0	3.0	3.2	3.1
1973	2.9	2.7	2.6	2.4
1974	2.1	2.0	2.1	2.0

CD purchasers

Federal Reserve Board surveys show that corporations are the primary source of funds for CD's. Funds needed for future events, such as tax and divident payments, find their way into CD's largely because of the flexibility of CD maturities. Roughly 70 percent of CD funds come from corporations; the next largest category, state and local governments, account for 10 to 15 percent of CD sales. The remaining sources of funds are bank trust funds, savings and loan associations, foreign central banks, and individuals.

By the end of 1961 New York City banks had over $1 billion in CD's outstanding, nearly $2 billion by the end of 1962, $4.5 billion in 1964, and $7.4 billion in mid-1966. Today, early 1975, the large New York City banks have over 30 billion in CD's outstanding and commercial banks across the country have over $80 billion outstanding. In terms of volume, the CD has become the U.S.'s most important money market instrument, not even exceeded by U.S. Treasury bills.

Empirical Work on CD's

While numerous articles and reports have been written on the CD, the number of studies involving empirical analysis--regression analysis--have been limited. Four studies were found involving CD's and of these, three involved the use of CD's by banks. The fourth study focused on corporate use of the CD for investment and liquidity purposes.

Gilbert Heebner's dissertation was the first study of CD's involving regression analysis [14]. Heebner sought to identify factors or variables that influenced negotiable CD volume. He first presented a list of hypotheses which he developed from "the benefit of viewpoints expressed by bankers and other participants in the CD market." The hypotheses were then tested by means of multiple regression analysis on monthly CD data for New York City banks classified as "weekly reporters" by the Federal Reserve System for the years 1962 to 1965. Regressions were run on unadjusted monthly data and on first differences in unadjusted monthly data.

Heebner's equations included both demand factors (demand for funds by banks) and supply factors (supply of funds to banks). Explanatory variables identified by Heebner as demand variables were: (1) average reserve position of eight banks in the previous month, (2) average total loans in New York banks in the following month, (3) average holdings of "other securities" in New York banks. Explanatory variables designated as supply variables were: (1) total corporate tax payments, (2) total (adjusted) corporate cash divident payments, (3) six month CD and Treasury bill interest differential, and (4) six month CD and finance company commercial paper interest differential.

Heebner rejected the regression results on the unadjusted monthly data because of extremely poor Durbin-Watson ratios which indicated the presence of serial correlations. However, the regression results on the first differences of the unadjusted data were statistically reliable and explained up to fifty percent of the monthly change in outstanding volume of CD's.

The results of Heebner's regression analysis may be subjected to serious questioning. Heebner's use of demand and supply variables in the same equation(s) is highly questionable. Heebner chooses to ignore identification problems with the use of multiple regression techniques. In addition one variable, six month CD and Treasury bill differential, identified as a supply variable, can just as easily be classified as a demand variable. In fact, any standard supply and demand analysis includes the price of the object in both the supply and demand relationships. Finally, several variables, although statistically significant, may not even be factors which affect either the demand for or supply of CD's.

Chronologically, the second study was Jerry L. Jordan's dissertation submitted to the University of California at Los Angeles in March, 1969 [17]. Jordan's study presented theoretical and statistical evidence on the determinants of an individual's decision to hold wealth in alternative forms of deposit type financial assets. Jordan dealt with demand and supply relationships for total time deposits at commercial banks, negotiable CD's, savings and loan association shares, and mutual savings bank deposits. He began his study with the development of a general theoretical framework for analyzing the demand for and supply of alternative financial assets.

Jordan's general demand function for the jth financial asset expressed in general equation form is as follows:

$$A_j^d = f\,(Yp,\ Ym,\ i_j,\ i_o,\ i_e,\ p_e,\ TC,\ IC,\ 0)$$

where

Yp = permanent income in constant prices

Ym = measured or realized income in constant prices

i_j = interest yield on the jth asset

i_o = interest yield on other assets

i_e = expected level of interest rates

p_e = expected price level

TC = transaction cost

a. travel to financial institutions

b. commissions on stock and bond transactions

IC = information cost and liquidity

a. risk and uncertainty

b. insurance

c. spot bid ask price spread

d. yield

e. other

0 = nonpecuniary returns

Hypothesized partials are as follows:

$$\frac{\partial Aj^d}{\partial Yp} > 0; \quad \frac{\partial Aj^d}{\partial Ym} > 0; \quad \frac{\partial Aj^d}{\partial ij} > 0; \quad \frac{\partial Aj^d}{\partial i_o} < 0$$

$$\frac{\partial Aj^d}{\partial i_e} < 0 \quad \text{(bonds and stocks)}$$

$$\frac{\partial Aj^d}{\partial i_e} > 0 \quad \text{(deposits; fixed current prices)}$$

$$\frac{\partial Aj^d}{\partial P_e} \gtrless ? \quad \text{(did not specify)}$$

$$\frac{\partial Aj^d}{\partial TC} < 0$$

$$\frac{\partial Aj^d}{\partial IC} < 0$$

$$\frac{\partial Aj^d}{\partial 0} \lesseqgtr 0 \quad \text{(did not specify)}$$

Jordan's hypothesis in verbal form is that the demand for a financial asset is a function of wealth, the expected monetary returns of the asset, the expected nonmonetary returns of the asset, monetary and nonmonetary returns of other assets, variances of return on each asset, costs of acquiring the asset, and uncertainty which may be associated with the asset concerning returns of principal, payment of interest, or liquidity.

Jordan's general framework for the supply of monetary assets was primarily aimed at explaining the supply of liabilities of deposit-type nongovernment financial intermediaries. Jordan's framework was developed in terms of a financial intermediary which holds only one type of earning monetary asset--mortgages. (Jordan, however, did believe his framework could be expanded to any number of type of earning assets.)

Jordan assumed the supply of deposit type asset A_j to be a function (positive) of the supply of earning assets (mortgages) to the supplier of A_j and a function (negative) of the cost of "intermediating." Jordan further asserted that a reduced form equation representing the supply of A_j would contain the following explanatory variables: a) those factors which influence the market supply of mortgages, b) those factors which influence the demand for mortgages by sources other than the supplier of A_j, and factors which represent other costs of operations incurred by the supplier of A_j. In addition the following assumptions were made by Jordan: a) the market supply of mortgages is negatively related to the interest rate paid on them (that is, the demand for funds from sources which offer mortgages as collateral is negatively related to the price paid for the funds, i.e., the interest rate); b) the demand for mortgages is a positive function of their yield. Jordan summarized his model with the assertion that (other things equal) "an increase in the total supply of mortgages will result in an increase in the supply of A_j, which in turn will result in a higher interest rate being offered for A_j, assuming no change in the demand for A_j."

In his analysis on CD's, Jordan used quarterly U.S. data from 1962 to 1967. His stated goal was to "provide evidence on the importance of some of the factors which affect the outstanding volume of CD's" [17, p. 130]. He hypothesized with respect to CD's that the quantity of CD's demanded would depend on the yield of CD's relative to the yield on risk-equivalent substitutes. He also asserted that interest rate expectations influenced the demand for CD's. While accepting the thought that different maturities of CD's would be influenced in perhaps totally opposite ways by interest rate expectations, Jordan asserted that the demand for CD's (as opposed to demand for a longer term security) as a short-term earning asset would be positively influenced by expected interest rates.

Jordan, faced with a limited sample size, included only a few explanatory variables in each equation. The variables used and their symbols are as follows:

r^{cd} = new issue rate on CD's maturing in six months

r^{t} = new issue rate on three month treasury bills

r^{1} = average rate paid on short-term business loans at large commercial banks

i^{e} = expected interest rate[6]

$\frac{r^{cd}}{r^{t}}$ = ratio of the new issue rate on CD's to the new issue rate on treasury bills

CP = corporate profits

FF1 = flow of funds wealth proxy--net acquisition of financial assets by all major sectors

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[6]The expected interest rate was generated according to the equation:

$$i^{e}_{t} = ni_{t-1} + (1 - n)\, i^{e}_{t-1}.$$

FF2 = FF1 plus gross savings of corporate nonfinancial business - and net surplus of state and local governments

BL = average outstanding business loans at large commercial banks

Analysis of Jordan's equations produced the following conclusions:

1. The demand for CD's was found to be highly responsive to the yields on CD's (positive) and negatively related to the cross yield on hypothesized substitutes.
2. The supply of CD's was found also to be responsive to yields on CD's, however, the value sign (positive) of the CD yield was opposite to that expected in a supply equation.[7]
3. The coefficient of the yield on business loans was also significant at the .05 percent level, but except for one case, also opposite to that expected.

Jordan's regression results are shown below:

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[7] Jordan felt that perhaps the small size of his samples used in regression may have contributed results contrary to those hypothesized. The presence of signs opposite to those hypothesized may also indicate the presence of identification problems.

	Supply Equation		Demand Equation	
	sign as hypothesized	significant at .05 level	sign as hypothesized	significant at .05 level
r^{cd}	- no	yes	+ yes	yes
r^{t}	not entered		- yes	yes
r^{l}	- no (with one exception)	mixed	not entered	
i^{e}	not entered		+ no	yes
$\frac{r^{cd}}{r^{t}}$	mixed	yes	+ yes	yes
CP	not entered		+ yes	yes
FF1	not entered		+ yes	yes
FF2	not entered		+ yes	yes
BL	- no (except one case)	yes	not entered	

The third study is that of Sandra B. Cohan, entitled "The determinants of supply and demand for certificates of deposit" [6]. Cohan first presented models to explain the supply price of both negotiable and non-negotiable CD's. A model was also developed to explain the demand for CD's by corporations and individuals. The predictions of these models were then tested by single equation regression analysis and then by two stage least squares.

Cohan builds her model upon the assumption that banks are concerned with both risk and yield and that within this framework will seek to meet new or additional loan requests (as might be associated with an upturn in the business cycle) by selling open market securities accumulated during periods of economic lull. However, as banks seek to satisfy loan demands their liquidity position is decreased. Rising yields on business loans, which accompany economic expansions, make it increasingly profitable to issue interest-bearing CD's at rates competitive with competing open market instruments. Thus, Cohan asserts, beyond a certain decrease in the liquidity position of banks, one should expect CD's to be used to further loan growth. Accompanying the increase in deposits growth resulting from the issuance of CD's, the banker should expect increased costs associated with interest payments. Thus Cohan asserts the supply of CD's can be expected to respond to anticipated strength in loan demand, to yields on loans, and to competitive liquid asset market rates. Ceiling restrictions set by the Federal Reserve Board, through Regulation Q, were also assumed to be a constraining factor.

Once a bank decides the level of CD's that it wishes it simultaneously arrives at a desired level of CD rates. It is assumed that banks make partial adjustments over a given interval (quarterly) to remove the discrepancy between desired and existing rates offered on CD's. Cohan presented the following adjustment model for negotiable CD's:

$$\Delta r_{CD} = \lambda (r_{CD}^{*} - r_{CD} - 1) + \epsilon_{CD}$$

where

r_{CD} = observed CD rate

r_{CD-1} = observed CD rate in the previous period

r_{CD}^{*} = unobserved desired CD rate

ϵ_{CD} = random disturbance term

λ = adjustment coefficient ($0 \leq \lambda \leq 1$)

λ is expected to be large as banks are in a position to adjust CD rates on a daily basis.

In the absence of a rate ceiling a bank following through the assumptions presented above would set its CD's according to the strength of loan demand, competing asset yields, and the availability of funds from other sources. Using the treasury bill rate r_{tb} as a proxy, an upward sloping curve AA' can be presented (Figure 1.3).

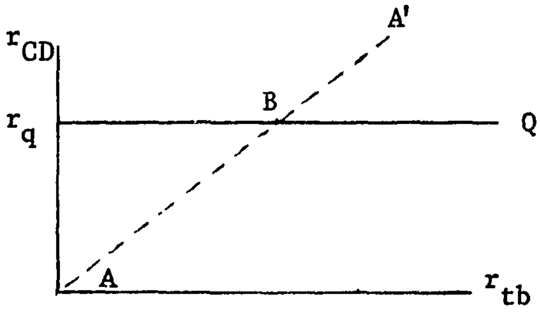

Figure 1.3. Individual offer function

Imposing ceiling r_q sets an upward limit on r_{CD} yielding an effective supply curve ABQ.

An aggregate supply relationship, taking into account that some banks may desire a rate greater than Regulation Q and some less than Regulation Q, produces the supply relationship presented in Figure 1.4.

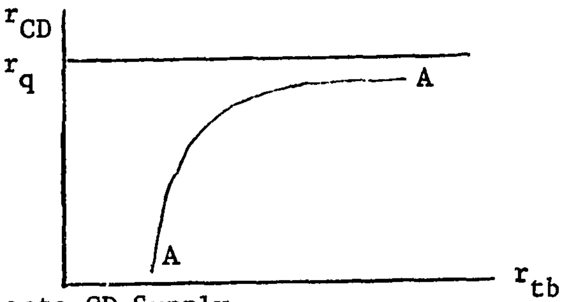

Figure 1.4. Aggregate CD Supply

Cohan's theory, presented in the previous two paragraphs, used the following transformation as an approximation [6]:

$$r_{CD}^{*} = \alpha - \beta \frac{1}{r_{tb}}$$

Further modification taking into account the theory of commercial bank behavior produced the following:

$$r_{CD}^{*} = r_q - r\ (r_q/r_{tb})$$

Combining the two equations yields:

$$r_{CD} = a_0 r_q - a_1 r_q/r_{tb} + a_2 r_{CD-1} + \varepsilon_{CD}$$

Empirical analysis of this model proved unsatisfactory and the equation was run again without suppressing the intercept term. Instead, a dummy variable D was introduced which took on values of 1 whenever the secondary rate on CD's exceeded Regulation Q ceilings and 0 otherwise.

Nonnegotiable CD's

Cohan assumed that a complete supply model for CD's by commercial banks should include an equation to explain the supply price of CD's (r_p). It was assumed that personal nonnegotiable CD's interest rates are in part determined by the same factors as negotiable CD rates (r_{CD}). Accordingly, the negotiable CD rate was included as an explanatory variable. Competitive liquid assets were represented by including savings and loan association rates r_{S1}, and commercial bank savings deposits interest rate r_{SD}. The short term bank loan rate r_{b1} was also included to reflect loan demand pressures. Expressed in the following linear equation the commercial bank supply price of personal CD's became:

$$r_p = b_0 + b_1 r_{SD} + b_2 r_{S1} + b_3 r_{CD} + b_4 r_{b1}$$

Model of Demand for CD's

The demand model presented seeks to explain the public's demand for CD's at weekly reporting large commercial banks. It is assumed that total liquid asset holdings are given, and the problem is one of determining what portion of these liquid assets will be held as CD's. Operating from the theory of consumer demand Cohan specifies the demand for CD's to be a function of their price, the prices of other liquid assets, income and tastes. Expressed in equation form total demand for CD/LA become:

$$CD/LA = C_0 + C_1 (r_{CD} - r_{tb}) + C_2 (r_p - r_{SD}) + C_3 W$$
$$+ C_4 (\Delta Y - K) + C_5 S_1 + C_6 S_2 + C_7 S_3$$

where:

r_{CD} = yield on CD negotiable

r_p = yield on CD nonnegotiable

r_{SD} = interest on savings deposit

W = wealth variable of the form $W = .139 \sum_{i=1}^{11} (.9)^i GNP_{-i}$

ΔY-K = transitory income where Y is current GNP and K is the average growth in GNP

S_1, S_2
S_3 = seasonal dummy variables

Ordinary least squares regression analysis using quarterly data covering 26 quarters from the third quarter, 1961, to the fourth quarter of 1967 for both the supply and demand equations produced the following results for negotiable CD's.

$$r_{CD} = \underset{(.0517)}{.8336\, r_q} - \underset{(.1976)}{2.6405\, r_q/r_{tb}} + \underset{(.0535)}{1.599\, r_{CD}} - \underset{(.0573)}{.1175\, D} + 2.818$$

$R^2 = .994$

$SE = .065$

$DW = 2.085$

$$CD/LA = -7.3633 + \underset{(.2239)}{.4188\, (r_{CD} - r_{tb})} + \underset{(.2367)}{.4615\, (r_p - r_{SD})}$$

$$+ \underset{(.4359)}{7.605\, W} - .0273\, (\Delta Y\text{-}k) - \underset{(.4894)}{.4096\, S_1} + \underset{(.1250)}{.2576\, S_2} - \underset{(.2794)}{.0878\, S_3}$$

$R^2 = .995$

$SE = .490$

$DW = 2.190$

Results for nonnegotiable CD's were as follows:

$$r_p = -4.2902 + \underset{(.1549)}{.8778\, r_{SD}} + \underset{(.1586)}{.8269\, r_{S1}} + \underset{(.0501)}{.1618\, r_{CD}} + \underset{(.0563)}{.1926\, r_{b1}}$$

$R^2 = .986$

$SE = .070$

$DW = 1.428$

In the nonnegotiable CD price regression each sign agreed with expectations and every coefficient was significant at the .01 level. The Durbin-Watson statistic was in the region of indeterminacy.

Cohan, bringing together her three-equation model, argues that the model represents a recursive system in which the values of the endogenous variables emerge in sequence [6]. The supply price of negotiable CD's is determined only by exogenous variables, the supply price of personal CD's is determined by both exogenous variables and one endogenous variable, the negotiable CD rate, and finally the demand for CD's is determined by exogenous variables, and both the negotiable and personal CD endogenous variables.

More specifically, Cohan asserted that her three equation model is a block recursive system composed of the two equation supply block and the one equation demand block. She asserted that while the disturbance terms in the supply block should, in principle, be interdependent there is no reason to suppose that the disturbance term in the demand equation is correlated with those in the supply block. On this basis the demand equation can properly be estimated by ordinary least squares with no simultaneity bias, while the supply block must be re-estimated to take account of the within-block simultaneity.

Cohan, to obtain consistent estimations for the supply prices of CD's, first obtained estimates for r_{CD} by using the supply equation specified earlier in the section on supply analysis. Replacing r_{CD} with predicted values from the r_{CD} supply equation and re-estimating by ordinary least squares, Cohan obtained the following TSLS estimate:

$$r_p = -4.3413 + \underset{(.1715)}{.8900}\, r_{SD} + \underset{(.1679)}{.8290}\, r_{S1} + \underset{(.0568)}{.1541}\, r_{CD} + \underset{(.0596)}{.1984}\, r_{b1}$$

$R^2 = .984$

$SE = .074$

$DW = 1.482$

Re-estimation by two stage least squares yields results quite close to those obtained from ordinary least squares. Coefficient signs remained unchanged and continued significant at the .01 level.

CHAPTER II. REGULATION Q'S HISTORY AND USE DURING THE 1960'S AND EARLY 1970'S

Bankers in 1961 justified their change in policy towards the issuance of CD's to corporations on the grounds that they felt it necessary to compete for funds that corporations were to an increasing extent placing in money market instruments. Corporate treasurers since the late 1930's made use increasingly of idle cash balances by acquiring money market instruments whose maturity coincided with their anticipated needs for funds. The characteristics of the money market and the majority of its instruments, high liquidity, and low capital and credit risk ideally suit the corporate treasurer seeking a return for his funds with a high degree of safety.

The development of the secondary market for CD's established the necessary characteristic of liquidity for the CD. Should the corporate treasurer discover an unexpected need for funds all that was necessary was the sale of the CD on the secondary market.

The size of the financial assets of the banks first issuing CD's helped allay any fears of credit risk. After all, these banks were among the largest in the U.S. and the pillars of U.S. financial markets. Money market instruments must also be attractive from the standpoint of yield. Given two instruments of equal liquidity and equal levels of risk the investor will surely be drawn to that instrument offering the greater return.

Regulation Q, which establishes interest rate ceilings on time deposits and hence CD's, serves as a limit to what banks can offer as yields on CD's. Other money market instruments have no limits and thus whenever market rates push above Regulation Q ceilings issuance of new CD's becomes extremely difficult. This chapter is presented to provide the reader with a background of Regulation Q and its use during the 1960's and early 1970's.

Regulation Q Rationale

It was the opinion of many bankers and other financial experts that the relatively high rates of interest paid by commercial banks on both demand and time deposits in the 1920's helped to set the stage for the banking collapse in the 1930's. Payment of high interest rates on deposits was believed to have forced many banks to seek lower quality and hence high yield loans and investments. Loans were made to corporations which stood little chance of weathering the economic slowdown which was to come in the 1930's.

To eliminate what was believed to be destructive competition among banks, regulation of interest paid on deposits was introduced during the bank "reforms" of the 1930's. Congress, in banking reform legislation (Banking Acts of 1933, 1935), prohibited the payment of interest on demand deposits by all Federal Reserve member banks and FDIC-insured nonmember banks. Congress also established limits to the amount of interest that could be paid on time and savings deposits. Responsibility for establishing interest rate ceilings on time and savings deposits was given to the Board of Governors of the Federal Reserve System for member banks and to the Board of Directors of the FDIC for insured nonmember banks.

Regulation Q first established a 3 percent limit on interest rates paid on all time and savings deposits in 1933. This limit was reduced to 2.5 percent in 1935. A schedule of maximum time deposit rates based upon maturities became effective in early 1936.

As can be seen from Table 2.1 Regulation Q ceiling rates went unchanged from 1936 to 1957. It should also be noted that market rates until the late 1940's were also relatively stable. Starting with the late 1940's market rates began to move upward, however for the most part they still remained below "Q" ceilings. During the 1950's and early 1960's the Board of Governors took the position that interest rate ceilings should keep pace with market yields which were then steadily increasing. Increases in rates during 1946 resulted in the first change to Regulation Q ceilings in over 20 years. During 1956 prime commercial paper was yielding 3.41 percent, three month Treasury bills were trading at an average of 2.67 percent, and savings and loan associations were, on the average, paying an effective rate of 3 percent. At the same time, commercial banks were paying an effective rate of 1.6 percent and suffering a relative decline in time deposits.

While rates permitted on time deposits greater than 90 days were raised one half of a percentage point in January, 1957, the maximum rate payable on time deposits of less than 90 days remained at one percent. The Board of Governor's justification for this was that "there was insufficient reason to prevent banks, in the exercising of management discretion, from competing actively for time and savings balances by offering rates more nearly in line with other market rates. By increasing the

Table 2.1. Regulation Q ceiling rates 1933-1966

November 1, 1933-July 19, 1966								
	Effective Date							
Type and maturity of deposit	Nov. 1, 1933	Feb. 1, 1935	Jan. 1, 1936	Jan. 1, 1957	Jan. 1, 1962	July 1, 1963	Nov. 1, 1964	Dec. 1, 1965
Savings deposits:								
12 months or more	3.00	2.50	2.50	3.00	4.00	4.00	4.00	4.00
Less than 12 months	3.00	2.50	2.50	3.00	3.50	3.50	4.00	4.00
Other time deposits:[a]								
12 months or more	3.00	2.50	2.50	3.00	4.00	4.00	4.50	5.50
6 months to 12 months	3.00	2.50	2.50	3.00	3.50	4.00	4.50	5.50
90 days to 6 months	3.00	2.50	2.00	2.50	2.50	4.00	4.50	5.50
Less than 90 days (30-89 days)	3.00	2.50	1.00	1.00	1.00	1.00	4.00	5.50

[a]Between July 1 and October 31, 1973 there was no ceiling for 4-year certificates with minimum denomination of $1,000.

Table 2.2. Regulation Q ceiling rates 1966-1973

	Rates July 20, 1966-June 30, 1973			
	Effective date			
Type of deposit	July 20, 1966	Sept. 26, 1966	Apr. 19, 1968	Jan. 21, 1970
Savings deposits	4.00	4.00	4.00	4.50
Other time deposits:[a]				
Multiple maturity:				
30-89 days	4.00	4.00	4.00	4.50
90 days to 1 year				5.00
1 year to 2 years	5.00	5.00	5.00	5.50
2 years or more				5.75
Single maturity:				
Less than $100,000:				
30 days to 1 year				5.00
1 year to 2 years	5.50	5.00	5.00	5.50
2 years and over				5.75
$100,000 or more:				
30-59 days			5.50	6.25
60-89 days			5.75	6.50
90-179 days	5.50	5.50	6.00	6.75
180 days to 1 year			6.25	7.00
1 year or more				7.50

[a]Maximum rates on all single maturity time deposits in denominations of $100,000 or more have been suspended. Rates on time deposits whose maturity was less than 90 days were suspended June 24, 1970 and all other rates (maturity greater than 90 days) were suspended May 16, 1973. Distinction between single and multiple maturity deposits was eliminated July 16, 1973.

Table 2.3. Regulation Q ceiling rates beginning July 1, 1973

Type of deposit	Effective date: July 1, 1973	Effective date: Nov. 1, 1973
Savings deposits	5.00	5.00
Other time deposits (multiple- and single-maturity):		
Less than $100,000:		
30-89 days	5.00	5.00
90 days to 1 year	5.50	5.50
1 year to 2 1/2 years	6.00	6.00
2 1/2 years or more	6.50	6.50
4 years or more in minimum denomination of $1,000	1.00	7.25
$100,000 or more	2.00	2.00

rate limitations only on savings deposits and on time deposits with maturities longer than 90 days, the Board continued to recognize the special thrift character of savings accounts and to preserve a differential between long term time deposits and short term time deposits representing essentially liquid balances" [2, 1959, p. 105].

With the exception of their views on time deposits with maturities under 90 days the Board of Governors from the late 1950's through the middle 1960's shifted their use of Regulation Q as a means of preventing "destructive competition" to a means of promoting competition among banks. Regulation Q ceilings were adjusted upward each year from 1962 to 1966. Justification expressed by the Board of Governors for the January 1, 1962 Regulation Q increase provided the foundation for the Board's position during the first half of the 1960's. The Board cited three reasons as to why the increase in Regulation Q ceilings would be beneficial: (1) the increase would enhance economic growth, (2) the increase would contribute to improving the U.S. balance of payments position, and (3) it would have a healthy effect on the management of individual banks. Growth was expected to result from the flow of bank funds to longer term assets. The Board believed that higher ceilings would "enable each member bank to determine the rates of interest it would pay in light of the conditions prevailing in its area, the type of competition it must meet, and its ability to pay" [2, 1961, p. 102].

Regulation Q during the 1960's also became known as a means of controlling the growth of bank credit since the flow of deposits into banks is one factor influencing the ability of banks to expand loans and investments [2, 1963, pp. 39-40]. By raising or lowering Regulation Q ceilings relative to market rates the Board of Governors realized it could influence the amount of time and savings deposits banks would be able to attract.

In July 1966, less than 6 months after its last increase in "Q" ceiling limits, the Board shifted back to a more traditional use of "Q" ceilings, that is as a means of reducing competition. However at the same time the Board also sought to use "Q" as a means of controlling bank credit expansion. Severe competition had developed between commercial banks and other financial institutions following the December 1965 increase in ceiling limits. Savings and loan associations suffered appreciable reductions in savings inflows as market rates increased and banks made use of the higher rates allowable on CD's to attract funds. In addition to the problems of rate competition between financial institutions, inflationary forces were present in the economy as a result of increased government expenditures largely associated with the Viet Nam War.

The Board of Governors in July 1966 also recommended that legislation be passed to distinguish between consumer-type deposits and money market CD's. Included in the proposed legislation was the recommendation that Congress broaden the authority of the Federal Reserve by allowing them to distinguish deposits by amounts in regulating rates and that it extend similar authority to the Federal Home Loan Board to determine maximum rates at savings and loan associations [2, 1966, pp. 97-98].

Congress concurred with the Board's recommendation and passed Public Law 89-597 in September 1966 giving the Board of Governors power to distinguish between deposits over and under $100,000 in establishing maximum rates for member banks. At the same time, the maximum rate on any time deposit under $100,000 (excluding passbook savings) was set at 5 percent. Like the June reduction this action was intended to limit rate increases caused by competition for household savings and to keep the growth of bank credit at a moderate pace [2, 1966, pp. 104-106].

During the remaining portion of 1966 market interest rates continued their upward trends of earlier months, and yields on prime 4 to 6 month commercial paper and 90 day U.S. Treasury bills exceeded maximum rates allowed under Regulation Q ceilings. At this time bankers saw their first real outflow of CD funds since the expanded use of CD's began in 1961. Bankers were not able to replace maturing CD's with new CD's and outstanding CD's declined by nearly $4 billion. In addition a marked slowdown took place in the growth of other time deposits and a corresponding slowdown in the growth of bank credit took place as well. Many banks were unable to meet loan requests of large corporations, many of whom were firms that had been doing business with a particular bank for years, and Wall Street coined another descriptive title "credit crunch."

The Federal Reserve Board, hoping to offset a developing sluggishness in the economy, moved towards a position of monetary ease in early 1967. With monetary ease came a reduction in tightness in money market rates. Once again market rates were below Regulation Q ceilings and banks were able to compete for money market funds with CD's. Regulation Q ceilings permitted banks to be competitive with money market instruments during the remainder of 1967 and through spring of 1968. At that time money market rates once again moved into the range above Regulation Q ceilings and banks were unable to compete as effectively as they did in previous periods.

In April 1968, the Board raised ceilings on large denomination CD's in order to give banks "some leeway to compete for interest sensitive funds" [2, 1968, pp. 69-70]. Market rates continued to climb through 1968 and by the end of 1969 the spread between yields on four to six month commercial paper and the ceiling rate on 3 to 6 month CD's was 3 full percentage points. The Board made no revisions in ceiling rates during 1969 and by the end of 1969 banks unable to renew maturing CD's lost over half of the $24 billion in CD's held in December 1968. Banks once again found themselves in a position of funds flowing out instead of in. Once again the Board of Governors sought to use Regulation Q as a means of controlling bank credit expansion along with Open Market policy. A continued high level of inflation was the Board's main justification for use of Regulation Q as a tool of constraint during 1969.

Recognising the effects of the outflows of funds upon banks and the money market the Board of Governors revised Regulation Q ceilings upward on January 21, 1970. The ceiling of each maturity classification of large CD was raised 3/4 percent, and a new classification of CD, those maturing in one year or more, was permitted to yield 7.50 percent.

Unsettled financial market conditions aggravated by the admission of the Penn Central Railroad that it was insolvent, lead the Board to suspend Regulation Q on CD's and other single maturity time deposits in denominations of $100,000 and over with maturities of 30 to 89 days in early June 1970. The admission of the Penn Central Railroad that it would not be able to pay off maturing commercial paper raised havoc with the commercial paper market. The Board believed that removing Regulation Q ceilings on short term CD's would help banks meet the anticipated heavy demands for short term credit from corporations unable to obtain funds from the issue of commercial paper [2, 1970, pp. 134-135].

Banks, in the early spring of 1973, were forced to rely upon CD issues with maturities of less than 90 days. Tight money market conditions forced money market rates on 90 day or greater instruments above Regulation Q ceilings. The Board, offering the rationale that it wanted member banks to be able to maintain a balanced structure of deposits, suspended Regulation Q ceilings on CD's maturing in 90 days or more. This suspension ended the Board's use of Regulation Q as a means of controlling bank's ability to compete for money market funds through the supply of CD's.

CHAPTER III. THE THEORETICAL MODEL

The basic model used in this study was developed by Dudley Luckett [20] to provide a theoretical structure for the more stringent credit standards adopted by banks during periods of tight money. Carl VanderWilt [28] and Steve Steib [26] have also used this model to explain respectively determinants of member bank borrowing from the Federal Reserve and Euro-dollar borrowings by U.S. banks. In each study a microeconomic portfolio optimization approach was used as the theoretical model in which to analyze bank behavior.

The complete model used in this study seeks to analyze the behavior of individual banks as issuers of large CD's by combining a microeconomic analysis with a stock adjustment model using lagged variables. A geometric lag distribution can be expressed as:

$$Y_t = a + F(X_t + \lambda X_{t-1} + \lambda^2 X_{t-2} + \ldots \lambda^N X_{t-n}) + e_t$$

$$0 \leq \lambda \leq 1 \qquad (1)$$

In this equation the effect of X on Y extends indefinitely into the past, however the coefficients of each of the X's decline in a fixed manner. Thus, the very distant values of X have very little effect upon the present Y.

Equation 1 can be viewed in two ways -- as an adaptive expectations model or as the partial adjustment or stock adjustment model. We shall use the stock adjustment model approach. In this approach, a desired level of Y at time t, Y_t^*, is expressed as a function of one or more explanatory variables (X_t) plus a disturbance term e_t; i.e.

$$Y_t^* = a + \beta X_t + e_t \tag{2}$$

Since the values of Y_t^* are not observable and hence cannot be measured, it is assumed that an attempt is made to match the actual level of Y to its desired level and that such an attempt is only partially successful. The relationship between Y_t^* and Y_t can be specified as:

$$Y_t - Y_{t-1} = \gamma(Y^* - Y_{t-1}) + e_t \tag{3}$$

where $0 > \gamma \leq 1$ and e_t is a random disturbance term. The coefficient γ is called the "adjustment coefficient" as it indicates the rate of adjustment of Y to Y^*.

In this study Y becomes the volume of CD's outstanding and the X's become those variables affecting the volume of CD's. The following model of an individual bank is used to specify the appropriate "X's."

A simplified balance sheet identity for an individual bank may be specified as:

$$R + GS + L = DD + TD + CD + FF + BF + E\$ \tag{4}$$

where:

R = reserves

GS = government securities

L = loans

DD = net demand deposits

TD = time and savings deposits

CD = certificate of deposit

FF = federal funds

BF = borrowings from the Federal Reserve

$E\$$ = Eurodollar borrowings

and R, GS, L, DD, TD, CD, BF ≥ 0; FF, $E\$ \gtreqless 0$.

If it is assumed that banks hold zero excess reserves, reserves may be expressed as:

$$R = r_1 \text{ (DD)} + r_3 \text{ (E\$ - E\$}_b) + r_2 \text{ (TD + CD)}^1 \tag{5}$$

where:

$E\$_b$ = the reserve-free Eurodollar borrowing base

r_1 = the reserve requirement on net demand deposits

r_2 = the reserve requirement on time and savings deposits

r_3 = the marginal reserve requirement on Eurodollar borrowing.

By substituting 5 into 4 and simplifying:

$$G + L = (1 - r_1) \text{ DD} + (1 - r_2)(\text{TD + CD}) + (1 - r_3) \text{ E\$}$$
$$+ r_3 E\$_b + FF + BF \tag{6}$$

The banker is assumed to manage his assets and liabilities in order to maximize the utility function,

$$U = u(\pi, S, A) \tag{7}$$

where:

π = profit

S = soundness

A = liquidity

---

[1]This reserve equation is for the post July, 1969 period and will be used throughout the development of this theoretical model.

Profit

Profits equal total revenue minus total costs. Total revenue may be written as:

$$TR = i_{GS}GS + i_L L + \delta_1 DD \tag{8}$$

where:

TR = total revenue

i_{GS} = the interest rate on government securities

i_L = the interest rate on loans

δ_1 = the service charge rate on demand deposits

Total costs may be written as:

$$TC = \delta_2 DD + i_{TD}TD + i_{CD}CD + i_{FF}FF + i_{BF}BF + i_{E\$}E\$ + K \tag{9}$$

where:

TC = total costs

δ_2 = the cost of servicing demand deposits

i_{TD} = the interest rate paid on time and savings deposits

i_{CD} = the interest rate paid on certificates of deposit

i_{FF} = the interest rate paid on federal funds

i_{BF} = the interest rate paid on Federal Reserve borrowings

$i_{E\$}$ = the interest rate paid on Eurodollar borrowings

K = fixed costs including the cost of servicing loans

By assuming that the cost of servicing demand deposits is equal to the service charge on demand deposits (i.e., $\delta_1 = \delta_2$) profits can be expressed as:

$$\pi = i_{GS}GS + i_L L - i_{TD}TD - i_{CD}CD - i_{FF}FF - i_{BF}BF - i_{E\$}E\$ - K \tag{10}$$

Liquidity

The banker's concern with liquidity is centered on his desire to meet obligations which will come due between the current period and his planning horizon, t + h. These obligations include deposit withdrawals, redemption of maturing certificates of deposit, loan requests[2], repayments of borrowings from the Federal Reserve, repayment of matured federal funds borrowings, and repayment of matured Eurodollar borrowings.

At time t the banker is certain about the amount of his borrowings from the Federal Reserve, federal funds borrowings, and Eurodollar borrowings which will come due between t and t + h. Future levels of loan requests and deposit withdrawals are unknown and accordingly the banker must form expectations of their respective changes during his planning horizon. Maturing obligations constitute uses of funds for the banker and are another source of his concern with liquidity.

Sources of funds available to the banker include government security liquidation, matured loan collection, sales (issues) of certificates of deposits, new borrowings from the Federal Reserve, increases in deposits, new Eurodollar borrowings and those reserves freed by deposit withdrawals. The banker, if loan default is ignored, knows with certainty the portion of his loan portfolio which will be repaid during the planning horizon. However, he must form subjective expectations about the levels of federal

[2]In any time period a banker faces a loan demand schedule and in this model loan requests are assumed to be those requests the banker chooses to meet. For a discussion of the customer relationship and the banker's decision to deny or meet loan requests, see [15, pp. 154-158].

fund borrowings, deposits, certificates of deposit, borrowings from the Federal Reserve and Eurodollar borrowings which will exist at t + h. While the banker does have some control over these levels his expectations will be influenced by his expectations of various interest rates and the rules and regulations of the regulatory agencies. For example, the difference between ceiling rates on CD's and the treasury bill rate will affect the banker's expectations regarding his ability to issue new CD's between t and t + h, and thus the expected level of CD holdings at t + h.

We shall base our definition of bank liquidity on the difference between sources and uses of funds. Liquidity then is defined as follows:

$$GS_t - a_1CD_t + E\Delta CD - a_2BF_t + E\Delta BF - a_3FF_t + E\Delta FF - a_4(1-r_3)E\$$$
$$+ E(1 - r_3)\Delta E\$ + a_5L_t - E\Delta L - Ea_6(1 - r_1)\Delta DD + E(1 - r_1)\Delta DD$$
$$- Ea_7(1 - r_2)TD_t + E(1 - r_2)\Delta TD + E(1 - r_2)\Delta TD - A\sigma = 0 \qquad (11)$$

which may be written as:

$$GS_t - a_5L_t + E[\Delta CD + \Delta BF + \Delta FF + (1 - r_3)\Delta E\$ + (1 - r_1)\Delta DD$$
$$+ (1 - r_2)\Delta TD - a_6(1 - r_1)DD_t - a_7(1 - r_2)TD_t - \Delta L] - a_1CD_t$$
$$- a_3BF_t - a_2FF - a_4(1 - r_3)E\$_t - A\sigma = 0 \qquad (12)$$

where:

E = expected value operator

Δ = change in the level of the indicated variable between t and t + h

a_1 = proportion of certificates of deposit holdings at t which will be redeemed between t and t + h

a_2 = proportion of federal funds borrowings at t which will be repaid between t and t + h

a_3 = proportion of borrowings from the Federal Reserve at t which will be repaid between t and t + h

a_4 = proportion of Eurodollar borrowings at t which will be repaid between t and t + h

a_5 = proportion of loans at t which will be collected between t and t + h

a_6 = proportion of demand deposits at t which will be withdrawn between t and t + h

a_7 = proportion of time and savings deposits at t which will be withdrawn between t and t + h

σ = the standard deviation of the distribution of $(\Delta CD + \Delta BF + \Delta FF + (1 - r_3)\Delta E\$ + (1 - r_1)\Delta DD + (1 - r_2)\Delta TD - a_6(1 - r_1)DD_t - a_7(1 - r_2)TD_t - \Delta L)$

A = measure of liquidity

If we assume that the distribution of changes in all sources and uses of funds combined is distributed with a known mean and standard deviation, then A is the only unknown in 12. This value A, becomes the number of standard deviations by which $E(\Delta CD + \Delta BF + \Delta FF + (1 - r_3)\Delta E\$ + (1 - r_1)\Delta DD + (1 - r_2)\Delta TD - a_6(1 - r_1)\ DD_t - a_7(1 - r_2)\ SD_t - \Delta L)$ may fall below the actual level without causing the banker to be unable to meet his needs for liquid funds.

Example

Suppose it is known that a banker expects from t to t + h, to issue \$1,000 in new CD's, borrow \$500 from the Federal Reserve, borrow \$1,000 in Federal Funds, borrow \$1,000 in the Eurodollar market, accept \$700 in demand deposits, accept \$200 in time and savings deposits, and meet \$1,200 worth of new loan demand.

Further assume that, between t and t + h, 30 percent of his CD holdings at t will mature ($a_1 = .30$), all of his borrowings from the Federal Reserve at t must be repaid ($a_2 = 1$), all of his Federal Funds at t must be repaid ($a_3 = 1$), 40 percent of his Eurodollar borrowings at t will mature ($a_4 = .40$), and 25 percent of his loan portfolio at t will mature ($a_5 = .25$). In addition suppose the banker expects 10 percent of his demand deposits to be withdrawn between t and t + h, and 7 percent of his savings and time deposits are expected to be withdrawn ($a_6 = .10$ and $a_7 = .07$).

If the standard deviation of $E[\Delta CD + \Delta BF + \Delta FF + (1 - r_3)\Delta E\$ + (1 - r_1)\Delta DD + (1 - r_2)\Delta TD - a_6(1 - r_1)DD_t - a_7(1 - r_2)TD_t - \Delta L]$ were known, a measure of the banker's liquidity could be obtained from his current portfolio (at t). The following values constitute one possible example:

Current Portfolio		Expected Changes
$CD_t = 3000$	$a_1 = .30$	$E(CD) = -.30\ (3000) + 1000 = 100$
$FF_t = 600$	$a_2 = 1.0$	$E(FF) = -1.0\ (600) + 1000 = 400$
$BF_t = 200$	$a_3 = 1.0$	$E(BF) = -1.0\ (200) + 500 = 300$
$E\$_t = 1500$	$a_4 = .40$	$E(E\$) = -.40\ (1500) + 1000 = 400$

$L_t = 6000$	$E(a_5) = .25$	$E(\Delta L) = -.25\ (6000) + 1200 = -300$
$DD_t = 4000$	$E(a_6) = .10$	$E(\Delta DD) = -.10\ (4000) + 700 = 300$
$TD_t = 1000$	$E(a_7) = .07$	$E(\Delta TD) = -.07\ (1000) + 200 = 130$
		$G_t = 500$

In this example the solution of Equation 12 yields $A\sigma$ = \$3200. If we assume σ = \$3200, then A = 1. If the distribution is normally distributed the banker has adjusted his portfolio in a manner which assures him of being able to meet his liquidity needs 84 percent of the time. If the standard deviation were \$1600, A would be 2. In this case the banker would be assured of meeting his liquidity needs 98 percent of the time, given the assumption of a normal distribution.

Soundness

Soundness serves as a measure of the bank's ability to withstand unexpected declines in its liabilities and unexpected declines in the value of its assets. It is a measure of the bank's ability to meet its obligations to its customers in the event of forced liquidation due to unexpected events such as local or national economic contraction.

The Federal Reserve's Form for analyzing bank capital (which is used to evaluate the bank's capital adequacy under assumed conditions of distress) provides the basis for the definition of soundness used here. This definition is expressed as the difference between the realizable value of the bank's assets in potential periods of contraction with an assumed maximum decline in liabilities which would accompany such a contraction.

$$S_t = R_t + s_2G_t + s_3L_t - s_4CD_t - s_5TD_t - s_6DD_t - BF_t$$
$$- FF_t - E\$_t \qquad (13)$$

where:

S_t = measure of soundness

s_2 = percentage of the current value of the bank's present holdings of government securities which would be realizable under assumed conditions of distress

s_3 = percentage of the current value of the bank's present holdings of loans which would be realizable under the assumed conditions of distress

s_4 = percentage by which the bank's current liabilities might decline, through attrition, under the assumed conditions of distress

s_5 = percentage by which the bank's current time and savings deposits might decline under the assumed conditions of distress

s_6 = percentage by which the bank's current demand deposits might decline under the assumed conditions of distress

Since R is a linear function of DD, TD + CD, and E\$ - $E\$_b$, a weight ($s_1$) can be defined such that:

$$s_1R = s_6r_1(DD) + s_5r_2TD + s_4r_2CD + r_3(E\$ - E\$_b) \qquad (14)$$

and the substitution of 14 into 13 simplifies to:

$$S_t = s_2G + s_3L - s_6(1 - r_1)DD - s_5(1 - r_2(TD - s_4(1 - r_2)CD$$
$$- (1 - r_3)E\$ - r_3E\$_b - BF - FF \qquad (15)$$

which is the algebraic specification of soundness to be used in this study.

Derivation of Desired CD Level

Having specified utility maximization model of bank behavior in which certificates of deposit enter the utility function through their effects on profits, soundness, and liquidity, the desired or equilibrium levels of CD's now need to be derived. The individual bank is viewed as having five alternative methods of acquiring needed reserves; liquidation of government securities, selling CD's, purchasing Federal Funds, borrowing from the Federal Reserve, and borrowing Eurodollars.

The banker is assumed to possess perfect knowledge with respect to Federal Reserve reserve requirements and it is further assumed that the bank's reserve needs may arise from increases in loan demand greater than existing funds, withdrawals of demand deposits and withdrawals of time and savings deposits, including maturing CD's which are not replaced. Differential calculus is used to derive those variables which the banker considers relevant to issuing CD's when faced with reserve needs and the assumed means of adjustment.

The total derivative of the utility function specifies the changes in utility for a given change in one or all of the variables. The total derivative of this model's utility function may be expressed as:

$$du = \partial u/\partial \pi \ d\pi + \partial u/\partial S \ dS + \partial u/\partial A \ dA \tag{16}$$

Since K is constant $d\pi$ (total derivative of profit) becomes:

$$d\pi = \partial\pi/\partial GS \ dGS + \partial\pi/\partial L \ dL + \partial\pi/\partial TD \ dTD + \partial\pi/\partial CD$$
$$+ \partial\pi/\partial BF \ dBF + \partial\pi/\partial E\$ \ dE\$ \tag{17}$$

The total derivative of soundness is:

$$dS = \partial S/\partial DD\ dDD + \partial S/\partial TD\ dTD + \partial S/\partial CD\ dCD + \partial E\$/\partial E\$\ dE\$$$
$$+ \partial S/\partial E\$\ dE\$ + \partial S/\partial GS\ dGS + \partial S/\partial BF\ BF + \partial S/\partial FF\ dFF \qquad (18)$$

By assuming σ constant, $E[\Delta CD + \Delta BF + \Delta FF + (1 - r_3)\Delta E\$ + (1 - r_2)\Delta DD + (1 - r_2)\Delta TD - a_6(1 - r_1)DD_t - a_7(1 - r_2)TD_t - \Delta L]$ constant, and the maturity structure of the banker's portfolio constant (a_1, a_2, a_3, a_4 and a_5 constant) the total derivative of liquidity reduces to:

$$dA = \partial A/\partial GS\ dGS + \partial A/\partial CD\ dCD + \partial A/\partial BF\ dBF + \partial A/\partial FF\ dFF$$
$$+ \partial A/\partial E\$\ dE\$ \qquad (19)$$

The partial derivatives of Equations 17, 18 and 19 may be evaluated using Equations 10, 12, and 15. The results are:

$$d\pi = i_{GS}dGS + i_L dL - i_{TD}dTD - i_{FF}dFF - i_{BF}dBF - i_{E\$}dE\$ \qquad (20)$$

$$dS = s_2dGS + s_3dL - s_6(1 - r_1)dDD - s_5(1 - r_2)dTD$$
$$- s_4(1 - r_2)dCD - (1 - r_3)dE\$ - r_3dE\$_b - dBF - dFF \qquad (21)$$

$$dA = 1/\sigma\ (dGS + a_5dL - a_1dCD - a_2dFF - a_3dBF - a_4dE\$) \qquad (22)$$

Then substituting Equations 20, 21 and 22 into the utility function, Equation 16 results in:

$$dU = \partial u/\partial \pi\ [i_{GS}dGS + i_L dL - i_{TD}dTD - i_{CD}dCD - i_{FF}dFF - i_{BF}dBF$$
$$- i_{E\$}dE\$] + \partial u/\partial S[a_2dGS + a_3dL - a_6(1 - r_2)dDD - a_5(1 - r_2)$$
$$dTD - a_4(1 - r_2)dCD - (1 - r_3)dE\$ - r_3dE\$_b - dBF - dFF]$$
$$+ \partial u/\partial A\ 1/\sigma[dGS + s_5dL - s_1dCD - s_2dFF - s_3dBF - s_4dE\$] \quad (23)$$

Factoring Equation 23 yields the total derivative of the utility function in the following terms:

$$dU = dGS[(\partial u/\partial\pi\ i_{GS} + \partial u/\partial S\ s_2 + \partial u/\partial A\ 1/\sigma) + dL(\partial u/\partial\pi\ i_L$$
$$+ \partial u/\partial S\ s_3 + \partial u/\partial A\ 1/\sigma\ a_5) - dTD(\partial u/\partial\pi\ i_{TD} + \partial u/\partial S\ s_5(1 - r_2)]$$
$$- dCD[\partial u/\partial\pi\ i_{CD} + \partial u/\partial S\ s_4(1 - r_2) + \partial u/\partial A\ 1/\sigma\ a_1]$$
$$- dDD[\partial u/\partial S\ s_6(1 - r_1)] - dE\$[\partial u/\partial\pi\ i_{E\$} + \partial u/\partial S\ (1 - r_3)$$
$$+ \partial u/\partial A\ 1/\sigma\ a_4] - dE\$(\partial u/\partial S\ r_3) - dFF(\partial u/\partial\pi\ i_{FF}$$
$$+ \partial u/\partial S + \partial u/\partial A\ 1/\sigma\ a_2) - dBF(\partial u/\partial\pi\ i_{BF} + \partial u/\partial A\ 1/\sigma\ a_3) \quad (24)$$

Desired levels of CD issues, CD^*, are those levels which provide the banker maximum utility under the constraints imposed by the bank's accounting balance sheet. Thus the necessary (first order) condition for utility maximization is that $dU = 0$ for all possible variations in the bank's accounting balance sheet, Equation 4. All possible variations in the balance sheet identity may be expressed as:

$$dGS + dL = (1 - r_1)dDD + (1 - r_2)dTD + (1 - r_2)dCD$$
$$+ (1 - r_3)dE\$ + dFF + dBF \quad (25)$$

Solving Equation 25 for dCD yields:

$$dCD = (1/1 - r_2)[dGS + dL - (1 - r_1)dDD - (1 - r_2)dTD$$
$$- (1 - r_3)dE\$ - r_3 dE\$_b - dFF - dBF] \quad (26)$$

Substituting Equation 26 into Equation 24 imposes the conditions of the balance sheet and yields:

$$dU = dGS(\partial u/\partial\pi\ i_{GS} + \partial u/\partial S\ s_2 + \partial u/\partial A\ 1/\sigma) + dL(\partial u/\partial\pi\ i_L$$
$$+ \partial u/\partial S\ s_3 + \partial u/\partial A\ 1/\sigma\ a_5) - dTD[\partial u/\partial\pi\ i_{TD} + \partial u/\partial S\ s_5(1 - r_2)]$$
$$- dDD[\partial u/\partial S\ s_6(1 - r_1)] - dE\$[\partial u/\partial\pi\ i_{E\$} + \partial u/\partial S\ (1 - r_3)$$
$$+ \partial u/\partial A\ 1/\sigma\ a_4] - dF\ [\partial u/\partial\pi\ i_{FF} + \partial u/\partial S + \partial u/\partial A\ 1/\sigma a_2)$$

$$- dE\$(\partial u/\partial S\ r_3) - dBF(\partial u/\partial\pi\ i_{BF} + \partial u/\partial S + \partial u/\partial A\ 1/\sigma\ a_3)$$

$$- 1/(1 - r_2)\ [dGS + dL - (1 - r_1)dDD - (1 - r_2)dTD$$

$$- (1 - r_3)dE\$ - r_3 dE\$_b - dFF - dBF]\ (\partial u/\partial\pi\ i_{CD}$$

$$+ \partial u/\partial S\ s_4(1 - r_2) + \partial u/\partial A\ 1/\sigma\ a_1) \qquad (27)$$

Factoring and simplifying Equation 27 results in:

$$dU = dGS[\partial u/\partial\pi\ i_{GS} - i_{CD}/(1 - r_2) + \partial u/\partial S\ (s_2 - s_4) + \partial u/\partial A\ 1/\sigma$$

$$(1 - a_1)(1 - r_2)] + dL[\partial u/\partial\pi\ (i_L - i_{CD}/(1 - r_2) + \partial u/\partial S$$

$$(s_3 - s_4) + \partial u/\partial A\ 1/\sigma\ (a_5 - a_1/1 - r_2)] - dTD[\partial u/\partial\pi$$

$$(i_{TD} - i_{CD} + \partial u/\partial S\ (s_5 - s_4)(1 - r_2) + \partial u/\partial A\ 1/\sigma - a_1]$$

$$- dDD[\partial u/\partial\pi\ (i_{CD}\ (1 - r_1) + \partial u/\partial S\ (1 - r_1)(s_6 - s_4)$$

$$- \partial u/\partial A\ 1/\sigma\ (1 - r_1)/(1 - r_2)\ a_1] - dE\$[\partial u/\partial\pi\ (i_{E\$} - i_{CD})$$

$$(1 - r_3)/(1 - r_2) + \partial u/\partial S\ (1 - r_3)(1 - s_4) + \partial u/\partial A\ 1/\sigma$$

$$(a_4 - a_1)(1 - r_3)/(1 - r_2)] - dE\$_b[\partial u/\partial\pi\ i_{CD} r_3/(1 - r_2)$$

$$- \partial u/\partial S\ r_3(1 + s_4) - \partial u/\partial A\ 1/\sigma\ r_3 a_1/(1 - r_2)]$$

$$- dFF[\partial u/\partial\pi\ (i_{FF} - i_{CD}/1 - r_2) + \partial u/\partial S\ (1 - s_4) + \partial u/\partial A\ 1/\sigma$$

$$(a_2 - a_1/1 - r_2)] - dBF[\partial u/\partial\pi\ (i_{BF} - i_{CD}/1 - r_2)$$

$$+ \partial u/\partial S\ (1 - s_4) + \partial u/\partial A\ 1/\sigma\ (a_3 - a_1/1 - r_2)] \qquad (28)$$

Equation 28 is the total derivative of the utility function under the conditions of the balance sheet identity. The first order conditions of utility maximization, or portfolio equilibrium, specify that dU = 0 for all variations in the independent variables and thus require that:

$$\partial u/\partial \pi \; (i_{GS} - i_{CD}/1 - r_2) + \partial u/\partial S \; (s_2 - s_4) + \partial u/\partial A \; 1/\sigma$$

$$(1 - a_1/1 - r) \;=\; 0 \qquad (29)$$

$$\partial u/\partial \pi \; (i_L - i_{CD}/1 - r_2) + \partial u/\partial S \; (s_3 - s_4) + \partial u/\partial A \; 1/\sigma$$

$$(a_5 - a_1/1 - r_2) \;=\; 0 \qquad (30)$$

$$\partial u/\partial \pi \; (i_{TD} - i_{CD}) + \partial u/\partial S \; (s_5 - s_4)(1 - r_2)$$

$$+ \partial u/\partial A \; 1/\sigma - a_1 \;=\; 0 \qquad (31)$$

$$\partial u/\partial \pi \; (i_{CD} \; (1 - r_1)/1 - r_2 - \partial u/\partial S \; (1 - r_1)(s_6 - s_4)$$

$$+ \partial u/\partial A \; 1/\sigma \; (1 - r_1)/1 - r_2 \; a_1 \;=\; 0 \qquad (32)$$

$$\partial u/\partial \pi \; [i_{E\$} - i_{CD}(1 - r_3)/(1 - r_2) + \partial u/\partial S \; (1 - s_4)(1 - r_3)$$

$$+ \partial u/\partial A \; 1/\sigma \; (a_4 - a_1)(1 - r_3)/(1 - r_2)] \;=\; 0 \qquad (33)$$

$$-\partial u/\partial \pi \; (i_{CD} r_3/1 - r_2) - \partial u/\partial S \;\; r_3(1 + s_4) - \partial u/\partial A \; 1/\sigma$$

$$r_3 \; a_1/1 - r_2 \;=\; 0 \qquad (34)$$

$$\partial u/\partial \pi \; (i_{BF} - i_{CD}/1 - r_2) + \partial u/\partial S \; (1 - s_4) + \partial u/\partial A \; 1/\sigma$$

$$(a_2 - a_1/1 - r_2) \;=\; 0 \qquad (35)$$

and that:

$$\partial u/\partial \pi \; (i_{BF} - i_{CD}/1 - r_2) + \partial u/\partial S \; (1 - s_4) + \partial u/\partial A \; 1/\sigma$$

$$(a_3 - a_1/1 - r_2) \;=\; 0 \qquad (36)$$

The above first order conditions are the general equilibrium conditions for a bank's portfolio as specified by our model. The purpose of this paper is to determine those variables considered by the banker in issuing CD's when faced with a need for reserves as a result of a loan demand greater than existing funds, withdrawal of time and savings deposits, or withdrawal of demand deposits--with the restriction that his alternative sources of funds are limited to liquidation of government securities, selling certificates of deposit, purchasing Federal Funds, borrowing from the Federal Reserve, and borrowing Eurodollars.

The equilibrium conditions implied by the model are derived for the choices of issuing CD's and liquidation of government securities, issuing CD's and borrowing Eurodollars, issuing CD's and purchasing Federal Funds, and issuing CD's and borrowing from the Federal Reserve.

If the banker experiences demand deposit withdrawals and uses issues of CD's and government securities to regain portfolio equilibrium, the balance sheet identity (25) requires that $(1 - r_2)dCD - dGS = -(1 - r_1)$ dDD. This returns the banker's portfolio to equilibrium with zero excess reserves.

By using the total derivatives of the utility function (24) and the necessary conditions of utility maximization a relationship among the respective variables can be derived under the assumption that CD issues and government security sales are the only available sources of funds.

The total derivative of the utility function can be expressed as:

$$dU = dGS[\partial U/\partial\pi \; i_{GS} + \partial U/\partial S \; s_2 + \partial U/\partial A \; 1/\sigma] - dCD[\partial U/\partial\pi \; i_{CD} + \partial U/\partial S \; s_4(1 - r_2) + \partial U/\partial A \; 1/\sigma \; a_1] - dDD \; \partial U/\partial S \; s_6(1 - r_1) \tag{37}$$

and since $(1 - r_2)dCD - dGS = (1 - r_1)dDD$ or $dDD =$ $-(1 - r_2)/(1 - r_1) \; dCD - dGS/1 - r_1$

$$dU = dGS[\partial u/\partial\pi \ i_{GS} + \partial u/\partial S \ s_2 + \partial u/\partial A \ 1/\sigma] - dCD[\partial u/\partial\pi \ i_{CD} + \partial u/\partial S \ s_4(1 - r_2) + \partial u/\partial A \ 1/\sigma \ a_1] + [(1 - r_2)dCD - dGS] [\partial u/\partial S \ s_6] \tag{38}$$

Equation 38 reduces to:

$$dU = dGS[\partial u/\partial\pi \ i_{GS} + \partial u/\partial S \ (s_2 - s_6) + \partial u/\partial A \ 1/\sigma \ ] - dCD[\partial u/\partial\pi \ i_{CD} + \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ a_1] \tag{39}$$

First order conditions require that:

$$\partial u/\partial\pi \ i_{GS} + \partial u/\partial S \ (s_2 - s_6) + \partial u/\partial A \ 1/\sigma \ = \ 0 \tag{40}$$

$$\partial u/\partial\pi \ i_{CD} + \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ = 0 \tag{41}$$

Which can be restated as:

$$\partial u/\partial\pi \ i_{GS} + \partial u/\partial S \ (s_2 - s_6) + \partial u/\partial A \ 1/\sigma = \partial u/\partial\pi \ i_{CD} + \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ a_1 \tag{42}$$

$$\partial u/\partial\pi \ (i_{GS} - i_{CD}) + \partial u/\partial S[s_2 + (s_4 - s_6)(1 - r_2)] + \partial u/\partial A \ 1/\sigma \ (1 - a_1) \ = \ 0 \tag{43}$$

With the assumption that Eurodollar borrowings and sales of CD's are the only available sources of funds by which a banker may adjust to a demand deposit withdrawal the adjustment that the banker must make is: $(1 - r_3)dE\$ + (1 - r_2) \ dCD = - (1 - r_1)dDD$.

The total derivative of the utility function (24) now becomes:

$$dU = -dCD[\partial u/\partial\pi \ i_{CD} + \partial u/\partial S \ (s_4)(1 - r_2) + \partial u/\partial A \ 1/\sigma \ a_1] - dE\$ [\partial u/\partial\pi \ i_{E\$} + \partial u/\partial S \ (1 - r_3) + \partial u/\partial A \ 1/\sigma \ a_4] - dDD [\partial u/\partial S \ s_6 \ (1 - r_1)] \tag{44}$$

Given that $(1 - r_3)dE\$ + (1 - r_2)dCD = -(1 - r)dDD$ Equation 44 now becomes:

$$dU = -dCD[\partial u/\partial \pi \; i_{CD} + \partial u/\partial S \; s_4(1 - r_2) + \partial u/\partial A \; 1/\sigma \; a_1]$$
$$- dE\$[\partial u/\partial \pi \; i_{E\$} + \partial u/\partial S \; (1 - r_3) + \partial u/\partial A \; 1/\sigma \; a_4]$$
$$+ [(1 - r_3)dE\$ + (1 - r_2)dCD](\partial u/\partial S \; s_6) \quad (45)$$

Equation 45 can then be reduced to:

$$dU = -dCD[\partial u/\partial \pi \; i_{CD} + \partial u/\partial S \; (1 - r_2)(s_4 - s_6) + \partial u/\partial A \; 1/\sigma \; a_1]$$
$$- dE\$[\partial u/\partial \pi \; i_{E\$} + \partial u/\partial S \; (1 - r_3)(1 - s_6) \; \partial u/\partial A \; 1/\sigma \; a_4] \quad (46)$$

The first order conditions are:

$$\partial u/\partial \pi \; i_{CD} + \partial u/\partial S \; (1 - r_2)(s_4 - s_6) + \partial u/\partial A \; 1/\sigma \; a_1 = 0 \quad (47)$$

$$\partial u/\partial \pi \; i_{E\$} + \partial u/\partial S \; (1 - r_3)(1 - s_6) + \partial u/\partial A \; 1/\sigma \; a_4 = 0 \quad (48)$$

Combining 47 and 48 produces:

$$\partial u/\partial \pi \; i_{CD} + \partial u/\partial S \; (1 - r_2)(s_4 - s_6) + \partial u/\partial A \; 1/\sigma \; a_1$$
$$= \partial u/\partial \pi \; i_{E\$} + \partial u/\partial S \; (1 - r_3)(1 - s_6) + \partial u/\partial A \; 1/\sigma \; a_4 \quad (49)$$

which may also be expressed as:

$$\partial u/\partial \pi \; (i_{E\$} - i_{CD}) + \partial u/\partial S \; (1 - s_4) + r_3(s_6 - 1) + r_2(s_4 - s_6)$$
$$+ \partial u/\partial A \; 1/\sigma \; (a_4 - a_1) = 0 \quad (50)$$

If the banker is allowed to choose only between Federal Reserve Borrowings and CD issues when adjusting to demand deposit withdrawals he must make the portfolio adjustment so that $(1 - r_2)dCD + dBF = -(1 - r_1)dDD$.

In this case the total derivative of the utility function is expressed as:

$$dU = -dBF[\partial u/\partial \pi \ i_{BF} + \partial u/\partial S + \partial u/\partial A \ 1/\sigma \ a_3] - dCD[\partial u/\partial \pi \ i_{CD}$$
$$+ \partial u/\partial S \ s_4(1 - r_2) + \partial u/\partial A \ 1/\sigma \ a_1] - dDD$$
$$[\partial u/\partial S - s_6 \ (1 - r_1)] \tag{51}$$

Substituting $(1 - r_2)dCD + dBF = - (1 - r_1)dDD$ into equation 51 yields:

$$dU = -dBF[\partial u/\partial \pi \ i_{BF} + \partial u/\partial S + \partial u/\partial A \ 1/\sigma \ a_3]$$
$$- -dCD[\partial u/\partial \pi \ i_{CD} + \partial u/\partial S \ s_4(1 - r_2) + \partial u/\partial A \ 1/\sigma \ a_1]$$
$$+ [(1 - r_2)dCD + dBF] \ (\partial u/\partial S \ s_6) \tag{52}$$

Equation 52 reduced to:

$$dU = -dBF[\partial u/\partial \pi \ i_{BF} + \partial u/\partial S \ (1 - s_6) + \partial u/\partial A \ 1/\sigma \ a_3]$$
$$- dCD[\partial u/\partial \pi \ i_{CD} + \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ a_1] \tag{53}$$

The first order conditions are:

$$\partial u/\partial \pi \ i_{BF} + \partial u/\partial S \ (1 - s_6) + \partial u/\partial A \ 1/\sigma \ a_3 = 0 \tag{54}$$

$$\partial u/\partial \pi \ i_{CD} + \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ a_1 = 0 \tag{55}$$

Equation 54 and 55 may also be written:

$$\partial u/\partial \pi \ i_{BF} + \partial u/\partial S \ (1 - s_6) + \partial u/\partial A \ 1/\sigma \ a_3 = \partial u/\partial \pi \ i_{CD}$$
$$+ \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ a_1 \tag{56}$$

which can also be written as:

$$\partial u/\partial \pi(i_{BF} - i_{CD}) + \partial u/\partial S[(1 - s_6) - (1 - r_2)(s_4 - s_6)]$$
$$+ \partial u/\partial A \ 1/\sigma \ (a_3 - a_1) = 0 \tag{57}$$

In the situation where CD issues and purchases of Federal Funds are the only source of funds available to the banker, he must adjust to demand deposit withdrawals so that $(1 - r_2)dCD + dFF = -(1 - r_1)dDD$.

With these conditions the total derivative of the utility function is:

$$dU = -dFF[\partial u/\partial \pi \ i_{FF} + \partial u/\partial S + \partial u/\partial A \ 1/\sigma \ a_2] - dCD[\partial u/\partial \pi \ i_{CD} + \partial u/\partial S \ s_4(1 - r_2) + \partial u/\partial A \ 1/\sigma \ a_1] - dDD[\partial u/\partial S \ s_6 (1 - r_1)] \tag{58}$$

Substituting $(1 - r_2)dCD + dFF = -(1 - r_1) dDD$ in Equation 58 yields:

$$dU = -dFF[\partial u/\partial \pi \ i_{FF} + \partial u/\partial S + \partial u/\partial A \ 1/\sigma \ a_2] - dCD[\partial u/\partial \pi \ i_{CD} + \partial u/\partial S \ (s_4)(1 - r_2) + \partial u/\partial A \ 1/\sigma \ a_1] + [(1 - r_2)dCD + dFF[\partial u/\partial S \ a_6] \tag{59}$$

Equation 59 simplifies to:

$$dU = dF[\partial u/\partial \pi \ i_{FF} + \partial u/\partial S \ (1 - s_6) + \partial u/\partial A \ 1/\sigma \ a_2] - dCD[\partial u/\partial \pi \ i_{CD} + \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ a_1] \tag{60}$$

The first order conditions are then:

$$\partial u/\partial \pi \ i_{FF} + \partial u/\partial S \ (1 - s_6) + \partial u/\partial A \ 1/\sigma \ a_2) = 0 \tag{61}$$

$$\partial u/\partial \pi \ i_{CD} + \partial u/\partial S \ (1 - r_2)(s_4 - s_6) + \partial u/\partial A \ 1/\sigma \ a_1 = 0 \tag{62}$$

which as in earlier procedures may be expressed as:

$$\partial u/\partial \pi \ (i_{FF} - i_{CD}) + \partial u/\partial S \ [(1 + r_2) \ s_4 + (1 + r_2 s_6)] + \partial u/\partial A \ 1/\sigma \ (a_2 - a_1) = 0 \tag{63}$$

In equations 43, 50, 57 and 63 the variables a banker must consider in establishing his behavior as a CD issuer when faced with demand deposit withdrawals are considered.

In these equations the banker is placed in the position of choosing among combinations of CD sales, Eurodollar borrowings, Federal Funds purchases, borrowing from the Federal Reserve, and government securities sales as sources of funds.

The same technique is used to determine those variables which are of interest to the banker in developing his behavior as a CD issuer when experiencing withdrawals of time and savings deposits.

When a banker chooses a combination of government securities sales and CD issues as a source of funds he must satisfy $(1 - r_2)dCD - dGS = - (1 - r_2)dTD$.

By substitution and simplification the first order conditions, under the balance sheet identity, are derived to be:

$$\partial u/\partial\pi \; [i_{TD} - i_{CD} - i_{GS} + i_{TD}/1 - r_2] + \partial u/\partial S \; [s_4 - s_2 + r_2 (s_4 - s_5)] + \partial u/\partial A \; 1/\sigma \; (a_1 - 1) \; = \; 0 \tag{64}$$

If the banker chooses between Eurodollars and CD's as alternative sources of funds, the balance sheet identity requires that $(1 - r_3)dE\$ + (1 - r_2)dCD = - (1 - r_2)dTD$.

The first order conditions with this constraint are:

$$\partial u/\partial\pi \; [i_{E\$} - i_{FF} \; (1 - r_3/1 - r_2) + i_{FF} - i_{CD}] + \partial u/\partial S \; [(1 - r_3) + s_5 \; (r_3 - r_2) + s_4 \; (r_2 - 1)] + \partial u/\partial A \; 1/\sigma \; (a_4 - a_1) \; = \; 0 \tag{65}$$

If the banker chooses between borrowing from the Federal Reserve and issuing CD's as alternative sources of funds, the balance sheet identity requires that $(1 - r_2)dCD + dBF = - (1 - r_2)dTD$.

With this constraint the first order conditions become:

$$\partial u/\partial \pi \, [i_{BF} - i_{CD} + i_{TD} - i_{TD}/1 - r_2] + \partial u/\partial S \, [(1 - s_5) - (s_4 - s_5)(1 - r_2)] + \partial u/\partial A \; 1/\sigma \, (a_1 - a_3) = 0 \tag{66}$$

If the banker chooses between Federal Funds and CD's to meet time and savings deposit withdrawals the balance sheet identity requires that $(1 - r_2)dCD + dFF = - (1 - r_2)dTD$.

Under this constraint the first order conditions reduce to:

$$\partial u/\partial \pi \, [i_{FF} - i_{TD}/1 - r_2 + i_{TD} - i_{CD}] + \partial u/\partial S \, [1 - s_4(1 - r_2) - r_2 s_5] + \partial u/\partial A \; 1/\sigma \, (a_2 - a_1) = 0 \qquad (67$$

Equations 64, 65, 66 and 67 provide the variables a banker considers in bringing his portfolio back to equilibrium when it has been placed in disequilibrium as a result of a decline in time and savings deposits.

The variables involved in the banker's decisions regarding his behavior as a CD issuer shall now be derived under the assumption that his need for reserves is a result of increased loan demand. The methodology is the same as that used in equations 37 through 67.

If the banker decides to make the necessary portfolio adjustments by issuing CD's and selling government securities the balance sheet constraint is that $(1 - r_2)dCD - dGS = dL$.

The first order conditions derived from Equation 24 may be expressed as:

$$\partial u/\partial \pi \; [i_{GS} - i_{CD} - i_L \, r_2] + \partial u/\partial S \; [s_2 - s_4 + r_3(s_4 - s_3)]$$

$$+ \partial u/\partial A \; 1/\sigma \; (a_1 - a_5 \, r_2 - 1) = 0 \qquad (68)$$

If the banker considers Eurodollar borrowings and CD's to meet increased loan demand the balance sheet identity constraint is that $(1 - r_2)dCD + (1 - r_3)dE\$ = dL$.

The first order conditions in this case are simplified to:

$$\partial u/\partial \pi \; [i_{E\$} - i_L \; (1 - r_2)] - [i_{CD} - i_L - (1 - r_2)]$$

$$+ \partial u/\partial S \; [1 - s_3(1 - r_2) - (s_4 - s_3)(1 - r_2)] + \partial u/\partial A \; 1/\sigma$$

$$[a_4 - a_1 - a_5 \; (r_2 - r_3)] = 0 \qquad (69)$$

If the banker decides to adjust his portfolio through CD sales and borrowing from the Federal Reserve the balance sheet identity constraint is that $(1 - r_2)dCD + dBF = dL$.

The first order conditions are then:

$$\partial u/\partial \pi \; (i_{BF} - i_L \, r_2 - i_{CD}) + \partial u/\partial S \; ((s_4 - s_3) \, r_2 - s_4)$$

$$+ \partial u/\partial A \; 1/\sigma \; r_2 \, a_5 = 0 \qquad (70)$$

When the banker adjusts to increased loan demand by selling CD's and purchasing Federal Funds the balance sheet identity requires that $(1 - r_2)dCD + dFF = dL$.

The first order conditions then become:

$$\partial u/\partial \pi \; [i_{FF} - i_L \, r_2 - i_{CD}] + \partial u/\partial S \; (s_3 r_2 + 1 - s_4)$$

$$+ \partial u/\partial A \; 1/\sigma \; (a_3 - a_1 - r_2 a_5) = 0 \qquad (71)$$

In summary, Equations 43, 50, 57, 63 through 71 contain the variables with which the banker is concerned when determining his desired level of CD's. The situations under which these variables were derived are demand deposit withdrawals, time and savings deposit withdrawals, and increased loan demand. The derived variables are:

r_3, r_2, $(i_{GS} - i_{CD})$, $(i_{BF} - i_{CD})$, $(i_{FF} - i_{CD})$,

$(i_{E\$} - i_{CD})$, $(i_{TD} - i_{GS} - i_{CD} + i_{TD}/1 - r_2)$,

$[i_{E\$} - i_{FF}(1 - r_3/1 - r_2) + i_{FF} - i_{CD}]$, $[i_{BF} - i_{CD} + i_{TD} - i_{TD}/1 - r_2]$, $[i_{FF} - i_{TD}/1 - r_2 + i_{TD} - i_{CD}]$,

$[i_{GS} - i_{CD} - i_L\, r_2]$, $[i_{BF} - i_L\, r_2 - i_{CD}]$, $[i_{FF} - i_L\, r_2 - i_{CD}]$,

$\partial u/\partial \pi$, $\partial u/\partial S$, $\partial u/\partial A$.

CHAPTER IV. THE ECONOMETRIC MODEL

In this chapter we shall present the econometric models which shall be used to examine the CD supply function derived from the theoretical model of Chapter III. The presence of multicollinearity among many of the variables leads to the elimination of the following variables from the CD supply function:

$$(i_{TD} - i_{GS} - i_{CD} + i_{TD}/1 - r_2),\ [i_{E\$} - i_{FF}(1 - r_3/1 - r_2) + i_{FF} - i_{CD}],\ (i_{BF} - i_{CD} + i_{TD} - i_{TD}/1 - r_2),$$
$$(i_{FF} - i_{TD}/1 - r_2 + i_{TD} - i_{CD}),\ (i_{GS} - i_{CD} - i_L\, r_2),$$
$$(i_{BF} - i_L\, r_2 - i_{CD}) \text{ and } (i_{FF} - i_L\, r_2 - i_{CD}).$$

Regulation Q ceilings impact upon CD offer rates whenever short-term money market rates rise above existing regulation Q ceilings and the use of Regulation Q by the Federal Reserve System as a means of controlling CD volume was discussed in Chapter II. A proxy for the effect of the presence of Regulation Q ceilings is included in our econometric analysis. This proxy is the difference between secondary market CD rates and the Regulation Q ceiling.

Since bankers' desires to issue CD's are commonly believed to be influenced by the strength of loan demand, the variable total loans is also included in our econometric analysis. This variable is consistent with the assumption of our theoretical model (page 40) that loan requests are those requests the banker chooses to meet.

Assuming linear relationships between CD volume and the dependent variables we obtain the following equation for CD supply:

$$CD^s_t = b_0 + b_1(i_{TB} - i_{CD}) + b_2(i_{FF} - i_{CD}) + b_3(i_{CDS} - QC) + b_4(i_{E\$} - i_{CD}) + b_5(i_{BF} - i_{CD}) + b_6(r_3) + b_7(r_2) + b_8L + (1 - \lambda)\ CD_{t-1} + 1_t$$

where: b_0, b_1, b_2, b_4, b_5, b_6, b_8, $(1 - \lambda)$ are assumed to be > 0 and b_3, $b_7 < 0$.

To eliminate the effects of multicollinearity among the interest rate differentials we shall estimate an equation in which one variable representing the summation of the individual interest rate differentials is substituted for the individual interest rate differentials. This equation becomes:

$$CD_t = b_0' + b_3'(i_{CDS} - QC) + b_6'(r_3) + b_7'(r_2) + (1 - \lambda)'(CD_{t-1}) + b_8'L + b_9'(Z) + 1_t$$

where:

$$Z = [(i_{TB} - i_{CD}) + (i_{FF} - i_{CD}) + (i_{E\$} - i_{CD}) + (i_{BF} - i_{CD})]$$

and b_0', b_6', b_8', b_9', $(1 - \lambda)'$ are assumed to be > 0

and b_3', $b_7 < 0$.

Interest rate differentials are assumed positive since an increase in the differential implies a decrease in the cost of CD's relative to the cost of other instruments. The coefficient on the reserve requirement on the time and savings deposit reserve requirement ratio (which includes CD's) is assumed negative while the coefficient on the Eurodollar borrowing reserve requirement is expected to be positive. An increase in the

Eurodollar reserve requirement increases the size of the adjustment required to regain balance following a given change in Eurodollar borrowings; while an increase in the time and savings deposit reserve requirement increases the effective cost of using CD's as an adjustment vehicle.

The existence of a simultaneous determination of CD issues and CD rates requires us to consider the use of two stage least squares techniques. To use these techniques we must specify a demand function.

In developing a demand function for CD's it is assumed that the supply of CD deposits is very elastic with respect to interest rates. Furthermore, investors are concerned with the interest rate differential between money market instruments. Wealth is considered an important variable; CD growth requires an increase in the amount of available funds. The supply function is:

$$CD^{s} = \alpha_0 + \alpha_1 \ (i_{CP} - i_{CD}) + \alpha_2 \ (i_{TB} - i_{CD}) + \alpha_3 \ (PI) + 1_t$$

where

i_{CP} = the commercial paper rate on one to four month commercial paper

PI = U.S. Personal Income, a proxy for wealth.

Interest rate differentials are assumed to be inversely related to the supply of CD deposits.

Investors are assumed to seek higher rates of return among money market instruments of the same maturity. The supply of CD deposits is assumed to be positively related to personal income.

Assumed equilibrium, $CD^{s} = CD^{d}$, the reduced form equation becomes:

$$i_{CD} = \beta_0 + \beta_1\ i_{TB} + \beta_2\ i_{FF} + \beta_3\ (CDS - QC) + \beta_4\ (i_{E\$})$$
$$+ \beta_5\ i_{BF} + \beta_6\ r_3 + \beta_7\ r_2 + \beta_8\ i_{CP} + \beta_9\ PI$$

where:

$$\beta_0 = b_0 - \alpha_0/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_1 = b_1 - \alpha_2/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_2 = b_2/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_3 = b_3/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_4 = b_4/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_5 = b_5/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_6 = b_6/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_7 = b_7/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_8 = \alpha_1/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

$$\beta_9 = \alpha_3/(b_1 + b_2 + b_4 + b_5 - \alpha_1 - \alpha_2)$$

The presence of autocorrelation in the error terms in many previous econometric studies suggests that corrective techniques may have to be applied in this study. Should it prove necessary the Cochrane-Orcutt iterative technique (C.O.I.T.) may be used [6].

In the presence of first-order serially correlated errors this procedure uses an (internal) ordinary least squares regression to form an initial guess of rho, the first order serial coefficient. The following iteration then occurs:

1. All data are transformed by rho (e.g., $X_t - \rho X_{t-1}$);

2. Regression is run on the transformed data;
3. The regression coefficients are multiplied into the original independent variables to recalculate the serially correlated errors;
4. A new estimate of rho is formed.

When rho changes by less than .005 from one iteration to the next or when some predetermined number of iterations has occurred (20 in the program used) iteration terminates and regression output is produced. A similar procedure was used for second order errors.

Even when the Cochrane-Orcutt technique, or any other similar autocorrelation correction technique, is used to correct autocorrelation problems, T-statistics and standard errors of the regression coefficient are biased when lagged dependent variables are present in simultaneous equations [19]. To correct this bias the "LAGDEP" feature of the computer programming system (Economic Software Package (ESP), editor Robert Rebello, Massachusetts Institute of Technology) used in the preparation of the linear regression analysis of this dissertation will be used. The "LAGDEP" feature revises the variance-covariance matrix and eliminates the influences of the lagged dependent variable. While not necessary, the "LAGDEP" feature will be used on all regression analysis in which autocorrelation is present in an equation with a lagged dependent variable.

Time Period and Data

While aggregate data on CD volume is available from early 1961, individual district data, on a regular basis, is only available from 1964. Thus, with the exception of several runs on aggregate data, the majority of the regression runs covered the time period from January 1964 to June 1973. June 1973 was chosen as a cut-off point because all Regulation Q ceilings were removed in May 1973 and there were not enough observations to expand analysis in the Regulation Q free period.

The data for each interest rate variable consists of 114 four-week (or five when a particular month contained five weeks) CD volume and total loan volume are monthly data based upon weekly averages, while personal income figures are monthly estimates. Interest rates are presented as percentages while CD figures and personal income figures are denominated in billions of dollars.

CHAPTER V. THE EMPIRICAL EVIDENCE

Overview

Results of linear regression analysis of the econometric models developed from the theoretical model presented in Chapter III are presented in this chapter. Regression techniques applied include ordinary least squares (O.L.S.), generalized least squares, and two-stage least squares. Equations are analyzed in both a dynamic--stock adjustment--and a static context. Data used in this analysis is from the period between January 1961 and June 1973. CD supply equations presented are estimated from aggregate data for the period from January 1961 to June 1973 and supply equations for four other geographic areas were estimated for the period from January 1964 to June 1973. (The areas considered were aggregate U.S. data, New York Federal Reserve District, Chicago Federal Reserve District, San Francisco Federal Reserve District, and all remaining Federal Reserve Districts.) In addition shorter time periods were used to estimate supply equations for aggregate U.S. data. (Included were the periods 1961-1965, 1962-1966, 1964-1968, 1965-1969, 1966-1970, 1967-1971, 1968-1972, and 1969-1973.)

Stock adjustment equations

Ordinary least squares estimates yielded unadjusted R^2 of at least .97 for the stock adjustment form of the CD supply function. These O.L.S. supply equations for the five geographic areas considered in this study for the period from 1964-1973 are presented in Table 5.1. Figures presented in parentheses on this table and all other tables are t values of the corresponding coefficient and those marked with an a are significant at the five percent level of confidence. The Durbin Watson statistic for those O.L.S. equations which have had the Cochrane-Orcott iterative technique applied from 1.69 to 2.07 [6].

In all but one case, that of "all remaining Districts," the first order technique produced Durbin Watson statistics in the acceptance range (1.72-2.49) of the null hypothesis. The null hypothesis in this instance states that autocorrelation is not present. The category "all remaining Districts" with its Durbin Watson of 1.69 fell just outside the acceptance region and is considered to be in a region of indeterminacy. In this region one can neither accept nor reject the hypothesis that autocorrelation is present. While satisfactory Durbin Watson statistics have been obtained by applying the Cochrane-Orcutt technique, the presence of a lagged endogenous variable, CD_{t-1}, may also have been a factor. As pointed out by Nerlove and Wallis [22], the Durbin Watson statistic is asymptotically biased towards two when used with ordinary least square estimations which include lagged endogenous variables.

Aggregate U.S. equations

Ordinary least square equations estimated for CD supply during the two time periods, 1961-1973 and 1964-1973, from aggregate data are quite similar in composition with each registering an unadjusted R^2 of over .99. In the estimate covering the longer period, five of the nine variables considered are both significant and carry the hypothesized sign, while in the shorter period four variables are both significant and carry the hypothesized sign. Variables from both time periods which are significant and carry the anticipated sign are: required reserves on

Table 5.1. Ordinary least squares estimates of the stock adjustment equation and corrections for autocorrelation and the presence of a lagged dependent variable CD_t

Equation No. and Correction	Time	Constant	$i_{TB} - i_{CD}$	$i_{FF} - i_{CD}$	$i_{CDS} - i_{QC}$
		ALL U.S. BANKS			
(1) None	1961-1973:6	3.18	-1.46	.0709	.9481
		(4.916)[a]	(-4.969)[a]	(.454)	(7.186)[a]
(1) C.O.I.T.		2.89	-1.44	.025	.855
		(3.247)[a]	(-4.370)[a]	(.1435)	(4.804)[a]
(1) C.O.I.T. and correction for lagged dependent		(3.185)[a]	(4.362)[a]	(.1433)	(4.7955)[a]
(2) None	1964-1973:6	2.91	-1.516	.0177	.9685
		(3.774)[a]	(-3.656)[a]	(.0857)	(4.000)[a]
(2) C.O.I.T.		2.523	-1.534	.0439	.9221
		(2.338)[a]	(-3.219)[a]	(.0181)	(2.888)[a]
(2) C.O.I.T. and correction for lagged dependent		(2.295)[a]	(-3.211)	(.0180)	(2.881)
		NEW YORK FEDERAL RESERVE DISTRICT			
(3) None	1964-1973:6	2.606	-1.276	.033	.779
		(4.4506)[a]	(-3.814)[a]	(.2159)	(3.738)[a]
(3) C.O.I.T.		1.888	-1.038	.048	.558
		(4.3061)[a]	(-4.128)[a]	(.4162)	(3.488)[a]
(3) C.O.I.T. and correction for lagged dependent		(4.224)[a]	(4.1268)[a]	(.4159)	(3.485)[a]

[a]Indicates t value significant at 5 percent level.

$E\$^{i} - CD^{i}$	$FD^{i} - CD^{i}$	L	r_3	r_2	CD_{t-1}
-.384	.112	.0164	10.64	-69.72	.9729
(-3.506)[a]	(3.4178)[a]	(3.317)[a]	(4.95)[a]	(-4.381)[a]	(54.76)[a]
-.284	.6090	.025	5.39	-78.33	.947
(-2.274)[a]	(3.4122)[a]	(3.7748)[a]	(1.79)	(-4.517)[a]	(39.83)[a]
(-2.245)[a]	(3.336)[a]	(3.4816)[a]	(1.744)	(-4.514)[a]	(35.72)[a]
(-.3567)	.438	.0183	10.04	-70.312	.967
(-2.558)[a]	(1.84)	(3.013)[a]	(3.869)	(-3.574)[a]	(45.800)[a]
-.281	.679	.028	4.744	-75.619	.941
(-1.834)	(2.088)[a]	(3.497)[a]	(1.301)	(-3.198)[a]	(33.95)[a]
(-1.821)	(2.059)[a]	(3.226)[a]	(1.270)	(-3.198)[a]	(30.431)[a]
-.220	.7037	.073	7.456	-23.99	.892
(-2.0506)[a]	(3.297)[a]	(3.421)[a]	(4.531)[a]	(-1.623)	(33.851)[a]
-.150	.459	.054	5.994	25.356	.930
(-1.8606)	(2.789)[a]	(3.327)[a]	(4.7027)[a]	(-2.280)[a]	(45.409)[a]
(-1.855)	(2.779)[a]	(3.279)[a]	(4.701)[a]	(-2.276)[a]	(44.133)[a]

Table 5.1. Continued

Equation No. and Correction	Time	Constant	$i_{TB} - i_{CD}$	$i_{FF} - i_{CD}$	$i_{CDS} - i_{QC}$
		CHICAGO FEDERAL RESERVE DISTRICT			
(4) None	1964-1973:6	.460	-.321	.015	.242
		(2.1618)[a]	(-2.645)[a]	(2.705)[a]	(3.307)[a]
(4) C.O.I.T.		.2909	-.235	.023	.159
		(1.688)	(-2.402)[a]	(.4917)	(2.6575)[a]
(4) C.O.I.T. and correction for lagged dep. variable		(-1.688)	(2.398)[a]	(.4908)	(2.646)[a]
		SAN FRANCISCO			
(5) None	1964-1973:6	.130	-.271	-.016	.1895
		(.5160)	(-2.722)[a]	(-.320)	(3.271)[a]
(5) C.O.I.T.		.165	-.2060	.0147	.137
		(.6974)	(-2.272)[a]	(-.319)	(2.530)[a]
(5) C.O.I.T. and correction for lagged dep. var.		(-.647)	(-2.271)[a]	(-.3182)	(2.530)[a]
		REMAINING DISTRICTS COMBINED			
(6) None	1964-1973:6	-.060	-.0189	-.005	.008
		(-.8106)	(-.4952)	(-2.748)[a]	(.384)
(6) C.O.I.T.		.087	.0207	-.0029	.022
		(-.019)	(-.7015)	(-.1963)	(1.283)
(6) C.O.I.T. and correction for lagged dep. var.		(1.32)	(.6937)	(-1.963)	(1.281)

$E\$^{i} - CD^{i}$	$FD^{i} - CD^{i}$	L	r_3	r_2	CD_{t-1}
-.794	.149	.0370	1.964	-3.45	.955
(-1.966)	(2.043)	(2.1665)[a]	(2.986)[a]	(.6468)	(25.1422[a]
.0554	.062	.018	1.689	-5.053	1.000
(-1.712)	(1.025)	(1.343)	(3.1561)[a]	(-1.175)	(32.052)[a]
(-1.704)	(1.0149)	(1.2833)	(3.135)[a]	(-1.174)	(30.003)[a]
-.5898	.062	.0271	1.065	-6.9883	.955
(-1.756)	(1.165)	(2.054)[a]	(1.518)	(-1.543)	(21.2002)[a]
-.0149	.011	.017	.948	-9.281	.991
(-1.625)	(.219)	(1.436)	(1.452)	(-2.22)[a]	(23.26)[a]
(-1.623)	(.2169)	(1.270)	(1.372)	(-2.224)[a]	(20.163)[a]
-.020	.019	.0397	-.489	-4.515	.7603
(-1.56)	(.5878)	(5.466)[a]	(-2.103)[a]	(-2.617)[a]	(16.489)[a]
-.173	.014	.021	.0218	-3.769	.9108
(-1.717)	(.8525)	(3.094)[a]	(.099)	(-2.725)[a]	(21.465)[a]
(-1.707)	(.8399)	(2.752)[a]	(.0950)	(-2.724)[a]	(18.3049)[a]

Table 5.1. Continued

Equation No. and Correction	R^2 [b]	$\bar{R}^2$ [c]	S.E.	D.W. [d]
	ALL U.S. BANKS			
(1) None	.9987	.9985	.583	1.407
(1) C.O.I.T.				2.079
(1) C.O.I.T. and correction for lagged dep. var.				
(2) None	.9965	.9960	.667	1.4261
(2) C.O.I.T.				2.0689
(2) C.O.I.T. and correction for lagged dep. var.				
	NEW YORK FEDERAL RESERVE DISTRICT			
(3) None	.9877	.9865	.510	1.365
(3) C.O.I.T.				1.7467
(3) C.O.I.T. and correction for lagged dep. var.				

[b] R^2 = coefficient of determination.

[c] $\bar{R}^2$ = R^2 adjusted for degrees of freedom.

[d] D.W. = Durbin Watson statistic.

Table 5.1. Continued

Equation No. and Correction	R^2	$\bar{R}^2$	S.E.	D.W.
		CHICAGO FEDERAL RESERVE DISTRICT		
(4) None	.9841	.9838	.1919	
(4) C.O.I.T.				2.001
(4) C.O.I.T. and correction for lagged dep. var.				
		SAN FRANCISCO		
(5) None	.992	.991	.164	1.5577
(5) C.O.I.T.				1.9948
(5) C.O.I.T. and correction for lagged dep. var.				
		REMAINING DISTRICTS COMBINED		
(6) None	.9948	.9939	.062	1.0546
(6) C.O.I.T.				1.9765
(6) C.O.I.T. and correction for lagged dep. var.				

Eurodollars, required reserves on CD's, total loans, and lagged CD's. The interest rate differential between the Federal Reserve discount rate and the CD rate carried the correct sign and was significant for the 1961-1973 period while in the shorter period it again carried the correct sign but was not significant at the five percent confidence level.

Other geographic areas

Ordinary least square estimates for New York, Chicago, San Francisco and all remaining Federal Reserve Districts' CD supply equations were similar to those obtained from aggregate data. Variables with the correct sign and significant in the New York equation were: the differential between the Federal Reserve discount rate and the CD rate, total loans, required reserves on Eurodollars, required reserves on CD's and lagged CD's. Significant and correct-in-sign variables for Chicago were: the differential between the Federal Reserve discount rate and the CD rate, total loans, required reserves on Eurodollars, and lagged CD's. San Francisco showed the following variables with correct signs and significant: Total loans and lagged CD's. The "remaining District" equation had required reserves on Eurodollars, total loans, and lagged CD's correctly signed and significant. Corrective procedures for the presence of autocorrelation (as indicated by low values for the Durbin Watson statistic) and a lagged dependent variable did not produce significantly different estimates for the respective supply equations. In general, the correction procedure for the presence of a lagged dependent variable uniformly lowered each coefficient's respective t value.

Recognizing that the lack of significance on many of the interest rate differential variables may partially be attributable to an identification problem, a two-stage least squares equation approach was used to eliminate the effects of the simultaneous determination of CD volume and CD rates. The two-stage least square equation results which were very similar to the O.L.S. estimates, are shown in Table 5.2. The two-stage least square approach did not add to the list of significant and correctly signed variables, however the autocorrelation correction technique did continue to produce Durbin Watson statistics in the acceptable range and the explanatory value of the equations, in terms of explained variation (R^2), remained high (each equation in excess of .98).

The presence of a relatively high degree of correlation between the rate differential variables led to the creation of an index variable (Z). Variable Z, obtained by converting the rate differentials to an index was used in place of the individual rate differentials in some of the two stage estimates. In each case it carried a negative coefficient, contrary to anticipation, and was significant in only one equation, that of "all remaining Districts."

The possibility of structural changes during the 12 year period between 1961 and 1973 led to two stage least square adjustment estimates involving shorter time periods. These estimates presented in Table 5.3 are based upon five year periods and are for U.S. aggregate data only. While several events happened in this 12 year period which would make convenient starting and stopping dates (for example the credit crunch in 1966 and 1969) it was believed that additional comparisons should be made

Table 5.2. Two stage least square estimates of stock adjustment equation with correction applied for autocorrelation and the presence of a lagged dependent variable CD_t

Equation No. and Correction	Time	Constant	$i_{TB} - \hat{i}_{CD}$	$i_{FF} - \hat{i}_{CD}$	$i_{CDS} - QC$
		ALL U.S. BANKS			
(1) None	1961-1973:6	2.626 (3.353)[a]	-4.175 (-3.579)[a]	.3562 (1.7018)	1.981 (4.386)[a]
(1) C.O.I.T.		.4967 (.4072)	-3.9807 (-2.319)[a]	.265 (1.151)	1.711 (2.438)[a]
(1) C.O.I.T. and Lag. Dep. Cor.		(.3625)	(-2.312)[a]	(1.144)	(2.433)[a]
(2) None	1964-1973:6	2.323 (2.462)[a]	-4.244 (-2.858)[a]	.336 (1.299)	1.978 (3.1876)
(2) C.O.I.T.		-1.076 (-.627)	-4.698 (-2.017)	.2680 (.892)	2.148 (2.185)
(2) C.O.I.T. and Lag. Dep. Cor.		(-.499)	(-2.077)[a]	(.873)	(2.151)
(3) C.O.I.T.	1964-1973:6	2.772 (2.8828)[a]			.4282 (2.5408)[a]
(3) C.O.I.T. and Lag. Dep. Cor.		(2.868)[a]			(2.452)[a]
		NEW YORK FEDERAL RESERVE DISTRICT			
(4) None	1964-1973:6	-1.43 (3.549)[a]	.104 (1.312)	.785 (.545)	.785 (1.688)
(4) C.O.I.T.		1.38 (2.4817)[a]	-1.67 (-1.809)	.140 (.9096)	.727 (1.824)
(4) Lag. Dep.		(2.46)[a]	(-1.809)	(.908)	(1.824)
(5) C.O.I.T.	1964-1973:6	1.49 (2.738)[a]			-.721 (-.815)
(5) Lag. Dep.		(2.722)[a]			(-.765)

[a]Indicates t value significant at 5 percent level.

$i_{E\$} - \hat{i}_{CD}$	$i_{BF} - \hat{i}_{CD}$	Z	L	r_3	r_2
-.2782	.7305		.015	17.739	-38.884
(-2.159)[a]	(3.649)[a]		(2.679)[a]	(5.023)[a]	(-1.939)
-.260	1.115		.0316	6.641	-22.027
(-2.159)[a]	(3.406)[a]		(3.607)[a]	(1.202)	(-.8820)
(-2.155)[a]	(3.242)[a]		(2.801)[a]	(1.159)	(-.878)
-.271	.6846		.016	17.290	-41.33
(-1.604)	(1.991)		(2.288)[a]	(3.998)[a]	(-1.571)
.008	1.586		.044	4.663	6.25
(.039)	(2.890)[a]		(3.798)[a]	(.639)	(.172)
(.0338)	(2.6928)[a]		(2.5162)[a]	(.615)	(.1688)
		-.2017	.0059	.785	-10.127
		(-2.58)[a]	(1.064)	(2.684)[a]	(-5.310)[a]
		(-2.57)[a]	(.990)	(2.625)[a]	(-5.268)[a]
-2.19	.608		.060	8.034	-21.37
(1.754)	(2.199)		(2.561)[a]	(2.580)[a]	(-1.01)
-.087	.4393		.044	7.24	-15.33
(-.843)	(1.844)		(2.233)[a]	(2.715)[a]	(-.939)
(-.838)	(1.840)		(2.18)[a]	(2.712)[a]	(-.937)
		-.058	.020	.388	-4.02
		(-1.785)	(1.68)	(2.71)[a]	(-3.33)[a]
		(-1.78)	(1.59)	(2.69)[a]	(-3.27)[a]

Table 5.2. Continued

Equation No. and Correction	Time	Constant	$i_{TB} - \hat{i}_{CD}$	$i_{FF} - \hat{i}_{CD}$	$i_{CDS} - QC$
		CHICAGO FEDERAL RESERVE DISTRICT			
(6) None	1964-1973:6	.362	-.735	.067	.392
		(1.557)	(-1.89)	(.976)	(2.397)[a]
(6) C.O.I.T.		.139	-.692	.066	.320
		(.699)	(-2.07)[a]	(1.17)	(2.25)[a]
(6) Lag. Dep.		(.699)	(-2.06)[a]	(1.16)	(2.24)[a]
(7) C.O.I.T.		.127			.011
		(.621)			(.387)
(7) Lag. Dep.		(.620)			(.360)
		SAN FRANCISCO FEDERAL RESERVE DISTRICT			
(8) None	1964-1973:6	-.087	-.680	.0254	.337
		(-.278)	(-1.856)	(.413)	(2.228)[a]
(8) C.O.I.T.		-.242	-.032	-.027	-.273
		(-.478)	(-.493)	(-.457)	(-.079)
(8) Lag. Dep.		(-.470)	(-.487)	(-.450)	(-.074)
(9) C.O.I.T.	1964-1973:6	-.335			.002
		(1.107)			(.076)
(9) Lag. Dep.		(-.8088			(.0634)
		REMAINING DISTRICTS COMBINED			
(10) None	1964-1973:6	-.095	-.270	-.024	.050
		(-.879)	(-.548)	(-2.478)[a]	(.673)
(10) C.O.I.T.		-.075	-.148	-.037	.033
		(-.796)	(-.476)	(-2.338)[a]	(.547)
(10) C.O.I.T. and Lag. Dep. Cor.		(-.687)	(-.475)	(-2.078)[a]	(.487)

$i_{E\$} - \hat{i}_{CD}$	$i_{BF} - \hat{i}_{CD}$	Z	L	r_3	r_2
-.065	.183		.032	3.072	.888
(-1.445)	(1.945)		(1.766)	(2.738)[a]	(.129)
-.024	.108		.017	2.69	.083
(-.629)	(1.303)		(1.000)	(2.77)[a]	(.014)
(-.625)	(1.290)		(1.000)	(2.76)[a]	(.014)
		-.021	.014	.054	-.888
		(-1.71)	(1.29)	(.925)	(-2.08)[a]
		(-1.70)	(1.16)	(.897)	(-2.06)[a]
-.055	.109		.036	1.73	-3.424
(-1.374)	(1.341)		(2.270)[a]	(1.680)	(-.544)
-.033	-.059		.028	.042	-1.149
(-.868)	(-1.319)		(1.748)	(-.489)	(-2.453)
(-.839)	(-1.151)		(.931)	(-.340)	(-2.403)
		-.037	.035	.071	-1.047
		(-2.591)[a]	(2.757)[a]	(-.960)	(-2.403)
		(-2.567)[a]	(2.698)[a]	(-.791)	(-2.402)
-.170	.070		.044	.402	-3.684
(-1.823)	(.786)		(4.785)[a]	(2.004)	(-2.758)[a]
-.240	.103		.039	.327	-3.145
(-1.762)	(.699)		(4.289)[a]	(1.972)	(-2.445)[a]
(-1.655)	(.582)		(3.298)[a]	(1.902)	(2.143)[a]

Table 5.2. Continued

Equation No. and Correction	CD_{t-1}	R^2 [b]	$\bar{R}^2$ [c]	S.E.	D.W. [d]
		ALL U.S. BANKS			
(1) None	.9857 (49.126)[a]	.998	.996	.662	1.216
(1) C.O.I.T.	.9318 (29.294)[a]	.997	.995		2.038
(1) C.O.I.T. and lag. Dep. Cor.	(21.186)[a]				
(2) None	.982 (41.1827)	.996	.994	.760	1.229
(2) C.O.I.T.	.896 (22.223)[a]	.997	.995	.674	2.059
(2) Lag. Dep. Cor.	(12.715)[a]				
(3) C.O.I.T.	1.034 (33.571)[a]	.996	.994	.729	1.445
(3) Lag. Dep. Cor.	(-30.901)[a]				
		NEW YORK FEDERAL RESERVE DISTRICT			
(4) None	.911 (31.681)[a]	.985	.981	.559	1.230
(4) C.O.I.T.	.949 (38.656)[a]	.992	.989	.408	1.55
(4) Lag. Dep.	(36.691)[a]				
(5) C.O.I.T.	.940 (28.67)[a]	.992	.990	.409	1.579
(5) Lag. Dep.	(25.92)[a]				

[b] R^2 = coefficient of determination.

[c] $\bar{R}^2$ = adjusted for degrees of freedom.

[d] D.W. = Durbin Watson statistic.

Table 5.2. Continued

Equation No. and Correction	CD_{t-1}	R^2 [b]	$\bar{R}^2$ [c]	S.E.	D.W. [d]
	CHICAGO FEDERAL RESERVE DISTRICT				
(6) None	.976 (24.822)[a]	.981	.977	.202	1.396
(6) C.O.I.T.	1.02 (29.628)[a]	.989	.986	.157	1.907
(6) Lag. Dep.	(26.831)[a]				
(7) C.O.I.T.	1.015 (25.858)[a]	.988	.985	.158	1.88
(7) Lag. Dep.	(22.09)[a]				
	SAN FRANCISCO FEDERAL RESERVE DISTRICT				
(8) None	.928 (17.719)[a]	.990	.987	.182	1.247
(8) C.O.I.T.	.931 (16.023)[a]	.993	.990	.154	1.919
(8) Lag. Dep.	(7.828)[a]				
(9) C.O.I.T.	.913 (16.924)[a]	.993	.991	.153	1.918
(9) Lag. Dep.	(9.778)[a]				
	REMAINING DISTRICTS COMBINED				
(10) None	.882 (14.782)[a]	.989	.985	.133	1.103
(10) C.O.I.T.	.923 (12.986)[a]	.990	.987	.207	1.987
(10) C.O.I.T. and Lag. Dep. Cor.	(11.451)[a]				

by moving the regression period across time. This was accomplished by taking the starting period as 1961-1965 and then adding a year while simultaneously dropping a year from the beginning.

The equations based upon U.S. aggregate data estimated for five year intervals did not differ markedly from the equations obtained from over the period 1961-1973, except that fewer variables were significant. The same high R^2 values, but not greater than the R^2 for the 1961-1973 period, suggest that no significant structural change has taken place. And, Chow tests performed upon equations for the subperiods 1961-1966 and 1967-1973 positively support this thought. The gradual decline in the value of the coefficient of the lagged CD value does suggest one important facet of bank behavior which will be discussed below.

Adjustment Coefficient

In a stock adjustment model the coefficient of the lagged dependent variable is assumed to be $(1 - \gamma)$, where γ is an adjustment coefficient. Thus we can obtain an estimate of γ by subtracting the coefficient of CD_{t-1} from one ($\gamma = 1$ - coefficient of CD_{t-1}). In this particular application γ represents how fast banks move to adjust their actual stock of CD's to their desired level (CD*). The relatively high values of the coefficient of the lagged dependent variable (CD_{t-1}) for each of the geographic areas estimated (1964-1973 equations) produces very low estimates of γ implying that bankers move slowly to adjust their CD's. However, the coefficient present in the equations estimated from shorter periods (from U.S. data) suggest that bankers move to adjust their CD

Table 5.3. Two-stage least squares estimates of stock adjustment equation using five year moving period with corrections for autocorrelation and the presence of a lagged dependent variable CD_t

Equation No. and Correction	Time	Constant	$i_{TB} - \hat{i}_{CD}$	$i_{FF} - \hat{i}_{CD}$	$i_{CDS} - QC$
		ALL U.S. BANKS			
(1) C.O.I.T.	1961-1965	1.010 (1.532)	-.263 (-.604)	.250 (1.532)	-.007 (-.212)
(1) Correction for presence of lag. dep. var.		(.812)	(-.597)	(1.527)	(-.209)
(2) C.O.I.T.	1962-1966	.216 (.233)	-1.556 (-3.112)[a]	.446 (1.989)[a]	-.009 (-.238)
(2) Correction for presence of lag. dep. var.		(.219)	(-3.089)[a]	(1.981)[a]	(-.235)
(3) C.O.I.T.	1963-1967	-3.657 (-2.079)	.851 (-1.347)	.361 (1.008)	.184 (2.615)
(3) Correction for presence of lag. dep. var.		(-1.841)	(-1.346)	(.995)	(2.300)
(4) C.O.I.T.	1964-1968	-2.104 (-1.759)	-.581 (-.624)	-.110 (-.415)	.714 (1.613)
(4) Correction for presence of lag. dep. var.		(-1.240)	(-.542)	(-.308)	(1.470)
(5) C.O.I.T.	1965-1969	.264 (.197)	-1.141 (-1.379)	.132 (.539)	.352 (.893)
Correction for presence of lag. dep. var.		(.184)	(-1.358)	(.539)	(.854)

[a]Indicates t value significant at 5 percent level.

$i_{E\$} - \hat{i}_{CD}$	$i_{BF} - \hat{i}_{CD}$	L	r_2	Z	CD_{t-1}
-.259 (-1.499)	.0138 (.051)	-.0036 (-.3397)			.999 (15.917)[a]
(-1.481)	(.050)	(-.322)			(14.865)[a]
-.431 (-2.295)[a]	.680 (3.369)[a]	.0213 (1.844)			.902 (15.53)[a]
(-2.244)[a]	(3.341)[a]	(1.723)			(14.196)[a]
-.733 (-3.043)[a]	.555 (2.504)[a]	.066 (4.456)[a]	1.138 (.276)		.556 (6.409)[a]
(-2.959)[a]	(2.447)[a]	(3.05)[a]	(.275)		(3.961)[a]
-.677 (-2.926)[a]	1.036 (3.747)[a]	.086 (5.009)[a]	-4.127 (-1.236)		.508 (4.959)[a]
(-2.876)[a]	(3.159)[a]	(2.453)[a]	(-1.170)		(2.137)[a]
-.709 (-3.774)[a]	.559 (1.795)	.027 (2.397)[a]	-0.246 (-.061)		.819 (12.063)[a]
(-3.763)[a]	(1.761)	(2.319)[a]	(-.059)		(9.064)

Table 5.3. Continued

Equation No. and Correction	Time	Constant	$i_{TB} - \hat{i}_{CD}$	$i_{FF} - \hat{i}_{CD}$	$i_{CDS} - QC$
(6) C.O.I.T.	1966-1970	1.143 (.410)	-.766 (-.681)	.075 (-.241)	.224 (.607)
(6) Correction for presence of lag. dep. var.		(.410)	(-.678)	(-.239)	(.580)
(7) C.O.I.T.	1967-1971	-3.656 (-.886)	-1.111 (-1.051)	-.115 (-.345)	-.413 (-.170)
(7) Correction for presence of lag. dep. var.		(-.883)	(-1.053)	(-.338)	(-.149)
(8) C.O.I.T.	1968-1972	-1.086 (.765)	-1.114 (-.789)	.326 (1.064)	.376 (1.641)
(8) Correction for presence of lag. dep. var.		(.763)	(-.782)	(1.032)	(1.592)
(9) C.O.I.T.	1969-6/73	-26.968 (-3.409)[a]	-1.157 (-.840)	.182 (.382)	.136 (.436)
(9) Correction for presence of lag. dep. var.		(-2.212)[a]	(-.840)	(.378)	(.409)

$E\$^{i} - CD^{\hat{i}}$	$BF^{i} - CD^{\hat{i}}$	L	r_2	Z	CD_{t-1}
-.568	1.19	.044	-2.861		.818
(-2.676)[a]	(2.762)[a]	(4.142)[a]	(-.552)		(13.39)[a]
(-2.659)[a]	(2.750)[a]	(4.069)	(-.534)		(9.962)[a]
-.283	.571	.035	3.538		.789
(-1.558)	(1.452)	(3.936)[a]	(.532)		(12.194)[a]
(-1.555)	(1.397)	(3.413)[a]	(.517)		(8.386)[a]
-.368	.758	.061	-2.211		.788
(-1.474)	(1.720)	(2.979)[a]	(-.356)		(7.685)[a]
(-1.442)	(1.699)	(2.971)[a]	(-.351)		(7.426)[a]
.0018	.366	.128	-2.98		.647
(.0087)	(.758)[a]	(4.16)	(-.865)		(6.73)[a]
(.0087)	(.743)[a]	(2.47)	(-.841)		(3.72)[a]

Table 5.3. Continued

Equation No. and Correction	R^2	$\bar{R}^2$	S.E.	D.W.
(1) C.O.I.T.	.998	.998	.233	1.928
(1) Correction for presence of lag. dep. var.				
(2) C.O.I.T.	.997	.992	.267	2.030
(2) Correction for presence of lag. dep. var.				
(3) C.O.I.T.	.994	.990	.340	1.950
(3) Correction for presence of lag. dep. var.				
(4) C.O.I.T.	.991	.986	.347	1.958
(4) Correction for presence of lag. dep. var.				
(5) C.O.I.T.	.979	.978	.472	1.812
(5) Correction for presence of lag. dep. var.				
(6) C.O.I.T.	.977	.971	.597	1.954
(6) Correction for presence of lag. dep. var.				
(7) C.O.I.T.	.991	.985	.617	2.012
(7) Correction for presence of lag. dep. var.				

Table 5.3. Continued

Equation No. and Correction	R^2	$\bar{R}^2$	S.E.	D.W.
(8) C.O.I.T.	.990	.985	.610	1.970
(8) Correction for presence of lag. dep. var.				
(9) C.O.I.T.	.997	.993	.777	1.874
(9) Correction for presence of lag. dep. var.				

holdings more rapidly. The coefficient from the 1964-1973 equations may also reflect the overall strong growth trend present in CD volume.

Static Equations

Correlation matrices revealed the existence of high correlation between the lagged dependent variable, CD_{t-1}, and many of the independent variables. The existence of such correlation between endogenous variables can be considered harmful in that estimates of the regression coefficients are imprecise [19]. To remedy this problem the equations were run without the presence of the lagged dependent variable CD_{t-1}. As such, without the presence of the lagged CD variable, these equations are of a static nature and accordingly may be misspecified. However, the presence of larger adjustment coefficients (smaller CD_{t-1} coefficients) obtained during periods when Regulation Q was for the most part above money market rates on such instruments as Treasury bills and commercial paper and a priori information obtained from informal interviews with bankers, suggests that bankers move rapidly to bring their CD issues to desired levels.

Static equations estimated by O.L.S. techniques (Table 5.4) and two-stage least squares (Table 5.5) were in general disappointing as fewer variables were significant than in the stock adjustment equations. In addition, the Cochrane-Orcutt technique was not completely successful in removing the presence of autocorrelation [4]. However, while the signs of the variables were disappointing, the unadjusted R^2's continued high, ranging from .854 to .959 for the O.L.S. equations and from .844 to

Table 5.4. Ordinary least squares estimates of the static equation with corrections for autocorrelation

Equation No. and Correction	Time	Constant	i_{TB} - CD	i_{FF} - i_{CD}	i_{CDS} - QC
		ALL U.S. BANKS			
(1) None	1961-1973:6	-5.021	-2.688	-.9368	1.4658
		(-1.691)	(-1.9415)	(-1.281)	(2.361)[a]
(1) C.O.I.T.	1961-1973:6	-35.337	-.884	-.292	.3804
		(-5.760)[a]	(-1.682)	(-1.208)	(.994)
(2) None	1964-1973:6	-5.40	-4.511	-1.835	2.907
		(1.549)	(-2.405)	(-1.979)	(2.663)[a]
(2) C.O.I.T.		4.824	-1.636	-.3806	1.075
		(.814)	(-2.303)[a]	(1.067)	(1.926)
		NEW YORK FEDERAL RESERVE DISTRICT			
(3) None	1964-1973:6	7.878	-2.543	-.6979	1.910
		(4.044)[a]	(2.2204)[a]	(-1.324)	(2.692)[a]
(3) C.O.I.T.		18.879	-.574	-.248	.362
		(1.417)	(-1.386)	(-1.204)	(1.104)
		CHICAGO FEDERAL RESERVE BANKS			
(4) None	1964-1973:6	.586	-.764	-.218	.654
		(1.043)	(-2.399)	(-1.043)	(3.445)
(4) C.O.I.T.		-4.332	-.0691	-.0585	-.007
		(-2.374)	(-.449)	(-.756)	(-.058)
		SAN FRANCISCO FEDERAL RESERVE BANKS			
(5) None	1964-1973:6	-3.579	-.3096	-.2121	.163
		(-8.508)	(-1.351)	(-1.855)	(1.228)
(5) C.O.I.T.		-.3416	-.0075	-.0122	-.063
		(-.1549)	(-.0477)	(-.1549)	(-.5095)

[a]Indicates t value significant at 5 percent level.

$E\$^{i} - CD^{i}$	$BF^{i} - CD^{i}$	L	r_3	r_2
-2.211	3.455	.254	-53.869	-268.06
(-4.489)[a]	(6.678)[a]	(22.716)[a]	(-6.352)[a]	(-4.067)[a]
-.3344	1.344	.385	-10.178	37.073
(-2.050)[a]	(3.091)[a]	(7.796)[a]	(-1.426)	(1.164)
-1.453	4.715	.2635	-48.078	-203.25
(-2.309)[a]	(4.701)	(19.594)[a]	(4.639)[a]	(2.399)[a]
-.279	1.972	.088	-12.641	9.30
(1.405)	(3.254)	(3.623)[a]	(1.607)	(.225)
-1.298	3.1106	.591	-.169	-169.12
(-3.657)[a]	(4.480)[a]	(11.475)[a]	(-.030)	(-3.465)[a]
-.067	.632	.234	4.2045	-6.93
(-.580)	(1.772)	(3.52)[a]	(.9037)	(-.294)
.340	.143	.391	-3.410	-10.134
(-3.281)	(1.073)	(15.138)	(-2.070)	(-1.361)
-.009	.174	.329	-.997	14.793
(-.2141)	(1.289)	(6.036)	(-.586)	(1.696)
-.108	.318	.284	-8.146	-8.925
(1.404)	(2.6303)	(23.474)	(-6.440)	(-8.59)
-.403	.093	.173	-2.2089	8.471
(-.9247)	(.6878)	(4.997)	(-1.251)	(.9409)

Table 5.4. Continued

Equation No. and Correction	Time	Constant	$i_{TB} - i_{CD}$	$i_{FF} - i_{CD}$	$i_{CDS} - QC$
		REMAINING FEDERAL RESERVE DISTRICTS			
(6) None	1964-1973:6	-.411 (-3.049)	-.1466 (-2.067)	.0010 (.0303)	.0647 (1.691)
(6) C.O.I.T.		-1.011 (-2.4416)	-.3686 (-.810)	.0244 (1.066)	.0245 (.6850)

$E\$^{i} - CD^{i}$	BF - CD	L	r_3	r_2
-.0535 (-2.183)	.1208 (3.336)	.1376 (17.094)	-1.958 (-4.81)	-3.384 (-1.037)
-.019 (-1.544)	.037 (.9761)	.1247 (6.196)	-.8165 (-1.604)	1.577 (.6026)

Table 5.4. Continued

Equation No. and Correction	R^2	$\bar{R}^2$	S.E.	D.W.
		ALL U.S. BANKS		
(1) None	.954	.952	2.751	.2693
(1) C.O.I.T.	.996	.992	.7566	.8944
(2) None	.931	.925	3.055	.2673
(2) C.O.I.T.	.994		.8798	.8684
		NEW YORK FEDERAL RESERVE DISTRICT		
(3) None	.854	.851	1.762	.3298
(3) C.O.I.T.	.989	.983	.486	1.1334
		CHICAGO FEDERAL RESERVE BANKS		
(4) None	.884	.881	.5081	.3426
(4) C.O.I.T.	.986	.982	.1787	1.4066
		SAN FRANCISCO FEDERAL RESERVE BANKS		
(5) None	.9587	.953	.3768	.3776
(5) C.O.I.T.	.989	.984	.1853	1.344
		REMAINING FEDERAL RESERVE DISTRICTS		
(6) None	.989	.983	.1175	.2973
(6) C.O.I.T.	.981	.978	.053	1.3936

Table 5.5. Two-stage least squares estimate of static equation with correction for autocorrelation

Equation No. and Correction	Time	Constant	$i_{TB} - \hat{i}_{CD}$	$i_{FF} - \hat{i}_{CD}$	$i_{CDS} - QC$
		ALL U.S. BANKS			
(1) None	1961-1973:6	-5.693 (-1.750)	-5.456 (-1.099)	-.661 (-.745)	2.521 (1.311)
(1) C.O.I.T.		-74.848 (-4.417)[a]	-.546 (-.1945)	-.244 (-.726)	.229 (.1877)
(2) None	1964-1973:6	-7.140 (-1.885)	-11.577 (-1.897)	-1.124 (-1.057)	5.576 (2.192)
(2) C.O.I.T.		-195.99 (-4.165)[a]	.1265 (-.034)	-.489 (-1.156)	.052 (.035)
		NEW YORK FEDERAL RESERVE DISTRICT BANKS			
(3) None	1964-1973:6	8.432 (4.011)[a]	1.192 (.337)	-.931 (-1.520)	.3316 (.221)
(3) C.O.I.T.		110.33 (3.876)[a]	-3.503 (-1.936)	-.0312 (-.133)	1.5941 (1.942)
		CHICAGO FEDERAL RESERVE DISTRICT BANKS			
(4) None	1964-1973:6	.4508 (.739)	-1.287 (-1.270)	-.152 (-.854)	.841 (1.979)
(4) C.O.I.T.		-3.714 (-1.873)	-.9420 (-1.403)	-.005 (1.973)	.371 (1.224)
		SAN FRANCISCO FEDERAL RESERVE DISTRICT BANKS			
(5) None	1964-1973:6	-4.082 (-9.445)[a]	-2.519 (-3.590)[a]	-.0205 (-.167)	1.022 (3.506)[a]
(5) C.O.I.T.		.194 (.079)	-1.18 (-1.703)	.058 (.658)	.441 (1.412)

[a]Indicates t value significant at 5 percent level.

$i_{E\$} - \hat{i}_{CD}$	$i_{BF} - \hat{i}_{CD}$	L	r_3	r_2
-2.128	3.811	.256	-47.53	-239.45
(-4.058)[a]	(4.710)[a]	(21.495)	(-3.41)[a]	(-2.866)[a]
-.321	1.218	.322	-11.879	322.94
(-1.433)	(2.314)	(10.321)[a]	(-1.338)	(.847)
-1.203	5.550	.268	-31.97	-133.55
(-1.822)	(4.15)[a]	(18.355)[a]	(-1.858)	(-1.231)
-.341	1.476	.399	-11.744	43.330
(-1.256)	(2.071)[a]	(9.045)[a]	(-1.171)	(.908)
-1.490	2.373	.5667	-9.318	-24.985
(3.880)[a]	(2.696)[a]	(10.262)[a]	(-.9358)	(-3.468)[a]
.1531	.9903	.2100	9.7913	31.7114
(.981)	(2.392)[a]	(3.131)[a]	(1.725)	(1.158)
-.337	.868	.393	-2.237	-14.881
(-2.95)	(3.684)	(14.101)	(-.744)	(-.828)
.037	.277	.277	.634	20.652
(.652)	(1.797)	(5.679)	(.299)	(2.038)
-.025	.6210	.2954	-2.954	14.608
(-.326)	(4.107)[a]	(24.074)[a]	(-1.485)	(1.177)
.023	.237	.166	-.044	17.114
(.404)	(1.513)	(4.848)[a]	(.020)	(1.640)

Table 5.5. Continued

Equation No. and Correction	R^2	$\bar{R}^2$	S.E.	D.W.
		ALL U.S. BANKS		
(1) None	.952	.948	2.818	.3229
(1) C.O.I.T.	.9975	.992	.7523	.8358
(2) None	.926	.920	3.149	.3081
2) C.O.I.T.	.995	.991	.832	.9081
		NEW YORK FEDERAL RESERVE DISTRICT BANKS		
(3) None	.9449	.939	1.816	.4062
(3) C.O.I.T.	.989	.983	.4835	1.075
		CHICAGO FEDERAL RESERVE DISTRICT BANKS		
(4) None	.875	.871	.528	.366
(4) C.O.I.T.	.920	.916		
		SAN FRANCISCO FEDERAL RESERVE DISTRICT BANKS		
(5) None	.961	.957	.3641	.3891
(5) C.O.I.T.	.990	.987	.188	1.4491

.961 for the two stage least squares equations. Variable Z, the index variable of interest rate differentials, replacing the individual interest rate differentials in several equations, was always insignificant and carried the wrong sign.

Evaluation of empirical results

The close fits between actual and estimated values of CD volume obtained from the static equations offers support to the assumption that bankers adjust their outstanding CD's rapidly. In addition, the close fits obtained from both the stock adjustment equations and the static equations overall provides positive evidence of the theoretical model's explanatory value (see Figure 5.1).

While the performance of the individual interest rate differential variables were disappointing, the often positive, though not significant coefficient of the Federal funds CD rate differential was consistent with the model's predictions. It is believed that the often significant, but incorrectly signed coefficient of the Treasury bill CD rate differential may be attributed at least partly to institutional factors. Bankers, as discussed in Chapter I, typically offer a yield on their CD's above that of similar maturity Treasury bills so as to insure that their CD's are competitive.

The strong positive relationship between total loan volume and CD's was as expected and is consistent with results obtained from earlier studies. The relatively small size of the loan coefficient, even in the static equation results, (for example equation 2, Table 5.4 has a loan coefficient of .268) appears to be inconsistent with much of the

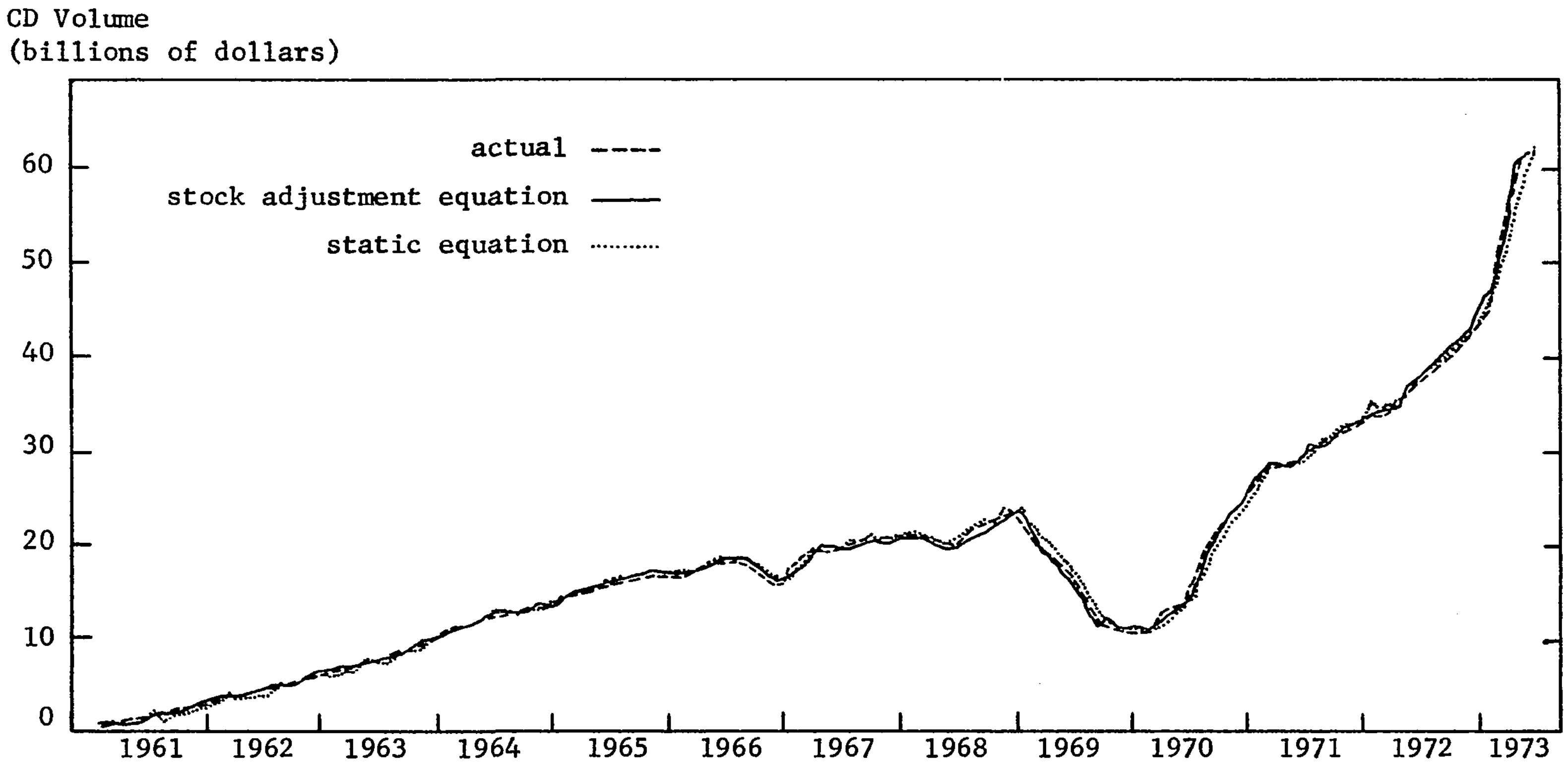

Figure 5.1. Two-stage least estimate of static equation and stock adjust equation for U.S. versus actual U.S. CD volume, January 1961 through June 1973 (monthly observations)

historical literature on CD's - inconsistent in that much of the literature claims that banks issue CD's primarily for loan use. The answer to this apparent inconsistency is that while a great many banks issue CD's, a few large banks continue to account for the bulk of CD issues.[1] Aggregate figures thus distort individual bank relationships.

The significant and consistent signs of the reserve requirements on both CD's and Eurodollars provides rationale for monetary authorities to use reserve changes as a means of implementing monetary policy and/or shifts in the composition of member bank liabilities.

[1]For example in the Atlanta Federal Reserve District in January 1972 while 552 banks had outstanding CD's, a few banks located in New Orleans, Atlanta, and Nashville accounted for 75 percent of the District's outstanding CD's. "Negotiable CD's reach record level at District Banks, Monthly Review, Federal Reserve Bank of Atlanta, July 1972.

CHAPTER VI. SUMMARY AND POLICY PROPOSALS

Summary

A description of the CD market in the U.S. has been presented. A utility maximization model has been combined with a stock adjustment model to explain the CD's issued by U.S. banks. Profits, supply liquidity, and soundness are entered as arguments in the utility maximization model. The empirical sample used in the examination of the model ran from January 1961 to June 1973 for all U.S. banks and from January 1964 to June 1973 for the four remaining areas considered. Empirical results were found to be consistent with the existing literature.

Policy Proposals

The continued significance of the reserve variables--required reserves on CD's and on Eurodollars--suggests that the Federal Reserve System has additional tools to control the expansion of bank credit. The results presented here support the November 1974 action of the Federal Reserve System. At that time the reserve requirement on all time deposits (including CD's) with maturities of at least 180 days and on the first $5 million of shorter-maturity time deposits was set at 6 percent. The Board's lowering of the reserve requirement on longer term deposits was intended to provide an incentive for banks to improve their liquidity by lengthening the maturities of their liabilities [3].

The discrepancy between the stock adjustment equations and the static equations with regard to the adjustment coefficient suggests a continued need for theoretical and empirical work on how banks adjust to a changing economic environment. Since monetary policy makers are often forced to assume primary responsibility for combating inflation, a better understanding of bank behavior would certainly aid the policy makers in applying their tools.

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APPENDIX: SOURCES OF DATA USED IN REGRESSION ANALYSIS

CD volume - - Federal Reserve Board's statistical release "Weekly Summary of Large Commercial Banks" (Form H 12).

i_{BF} - - - - - Federal Reserve Bulletin.

i_{CD} - - - - - Weekly range figures were obtained from the Federal Reserve Bank of New York. Midpoints of each range were used as the value.

i_{CDS} - - - - Secondary Market rates on CD's with 90 day maturity obtained from Federal Reserve Board tapes.

i_{CPR} - - - - Commercial paper rate on four to six month paper--Federal Reserve Bulletin.

$i_{E\$}$ - - - - - Federal Reserve Board tapes.

i_{FF} - - - - - Federal Reserve Bulletin.

i_{GS} - - - - - Federal Reserve Bulletin.

r_1 - - - - - Reserve requirements on demand deposits at Reserve City banks in excess of five million dollars--Federal Reserve Bulletin.

r_2 - - - - - Reserve requirements on time and savings deposits in excess of five million dollars--Federal Reserve Bulletin.

r_3 - - - - - Marginal reserve requirement on Eurodollar borrowings--Federal Reserve Bulletin.

L - - - - - Federal Reserve Board's statistical release "Weekly Summary of Large Commercial Banks" (Form H 12).